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ABSTRACT

Presented is the Annual Report for Resources For The Future, Inc. (RFF) for the year ending September 30, 1971. This organization is dedicated to advancing the development, conservation, and use of natural resources and the improvement of the quality of the environment through programs of research and education. Most of their studies are in the field of the social sciences. Document content includes an essay by the group's president, Joseph L. Fisher, entitled "A New Synthesis of Economic Development and Environmental Protection," and two special articles, "Man and His Environment: The Issues in Perspective," and "The Scrambled Pattern of Suburban Land Conversion" both by RFF members. Educational and research programs conducted in the following areas are described: quality of the environment, natural environments, land and water resources, energy and minerals, regional and urban studies, appraisals and special projects, and Latin American programs. A list of RFF publications, staff activities and writings, and a financial statement are also reported. (BL)

ANNUAL REPORT 1971

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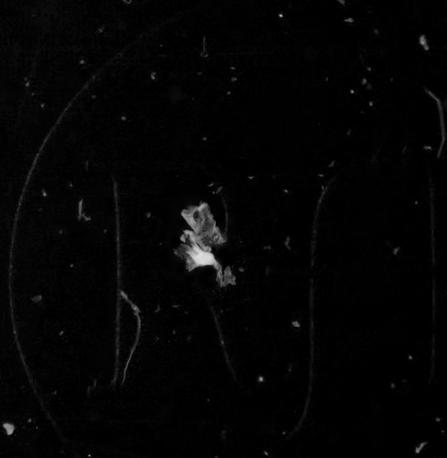

Resources for the Future, Inc.

SE 013 437

Resources for the Future, Inc. is a nonprofit tax-exempt corporation chartered under the laws of the state of New York, with headquarters in Washington, D.C. It was established in October 1952 with the cooperation of the Ford Foundation. Its purpose is to advance the development, conservation, and use of natural resources and the improvement of the quality of the environment through programs of research and education. Some of its programs are carried out by the resident staff; some are supported by grants to universities and other nonprofit organizations. Most of its studies are in the field of the social sciences.

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RESOURCES FOR THE FUTURE

Annual Report

for the year ending 30 September 1971

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THE PRESIDENT'S ESSAY

A New Synthesis of Economic Development and Environmental Protection

by Joseph L. Fisher

The 1960s opened on an optimistic note; economic development was the password, and goals were stated in terms of raising levels of living around the world by three, four, or five percent each year. In the United States the idea was to recapture lost momentum through an infusion of youthful vigor and policies that favored economic growth. In the populous but less-developed parts of the world agricultural science and technology, community development, and establishment of basic industry were to be the engines of growth — all lubricated by technical and financial aid from the wealthier countries. Lines could be extended on graph paper to show that the two billion poor people of the world could hope for the European or even the U.S. material levels of well-being by the end of the century. The possibilities were euphoric.

By the end of the 1960s dark clouds were everywhere in the sky. In many of the less-developed countries growth rates in aggregate production and income barely kept ahead of population increase. In the United States inflation persisted, the rate of economic growth slowed down, and unemployment became uncomfortably high. The term "stagflation" was coined.

Excluding the excruciating experience of the war in Southeast Asia and the threat of war elsewhere, two other problems were greatly intensified during the 1960s. First was the social problem of the cities — a compound of poverty, racial segregation, congestion, and a serious weakening of the ability of governments to cope with the situation. The second problem, not unrelated to the first, was the increasing deterioration in many places of the natural and physical environment of landscape, water, air, physical structures and arrangements, and amenities of living generally. In a broad sense the physical deterioration was real, but it was greatly exacerbated by the rising level of expectation about the quality of the environment. During the closing years of the 1960s more and more people began to ask why this country, with all its

technology, business enterprise, and finance, could not do a better job of improving the natural environment.

The long-neglected discipline of ecology came forward to supply a few broad concepts to undergird the environmental movement which blossomed nearly everywhere in the country. First here and there, and then in many places, the developers were put on the defensive. Plaintiffs were admitted to the courts to press for the public interest in a cleaner environment. Legislators at the various levels of governments scurried to attach their names to bills for clean air and clean water. Many young people, particularly from more comfortably situated families, took up the battle. Some of the fears of the eco-people were exaggerated and some of the actions they espoused were ill-advised. But, as the nation entered the 1970s their message, whether shrill or subdued, was being heard. The American political, economic, and social system began to feel the impact deeply and began the process of accommodation and adjustment amid much complaint and confusion.

■ If the early 1960s can be characterized in terms of the development thrust and the late sixties in terms of the environmental thrust, then what about the 1970s? In my view, the 1970s ought to be characterized by a synthesis of development with environmental protection, across a broad front of human concerns and working through a variety of programs and institutions. The synthesis will not be easily or quickly attained. Modes of behavior will have to change, as will the private and public institutions through which, increasingly, human activity is expressed. New theories and methods of analysis will have to be developed as a means of projecting the consequences of present economic and population trends as they bear upon both the natural and social environment. More consistent sets of policies will be required for dealing with such hard problems, to name a few examples, as (1) the demand for energy and alternative sources of supply, (2) the planning and use of land and related water on a more consistent basis, (3) the management of the enormous amounts of residual and waste materials thrown off daily by American producers and consumers, (4) the reconciliation of resource requirements and supplies on an international scale, (5) the reordering of research and development efforts more effectively to serve human needs, (6) the employment of tax, regulatory, and incentive measures in a more rational way, and (7) the overhauling of governmental and private processes by which priorities are set and decisions made with regard to resource and environmental matters. Informational and educational programs will be required if people are to participate effectively in large-scale programs and to understand what they are doing. Without progress on all of these fronts it seems unlikely that a new synthesis of development with environmental protection will be achieved in the 1970s.

In short, the challenge for the next decade will be to balance off

the drive for resource and economic development with the need to soften its harsher effects. The challenge will be to force the nation's attention to the longer view of man on earth and to the conditions for his survival and well-being. In particular, the new synthesis of development and protection will require that urban people and urban institutions become aware of the ecological constraints of earth, water, and atmosphere within which they must live.

It will be helpful to sort out the several kinds of environmental disruption according to their major effects and characteristics: the localized and worldwide; the short-lived and the long-lived; the reversible and the irreversible; those which seriously affect human health, genetic stock, and sustaining capacity of whole ecological systems and those which are merely nuisances; those whose perpetration and whose consequences can readily be ascribed to particular individuals and organizations and those whose effects spread widely to innocent bystanders downstream or downwind or in another country. Finally such a new synthesis will have to be based on an organic view of the world in which everybody and everything are interconnected and mankind is truly one family trying to establish a better home on spaceship earth.

■ Resources for the Future has been grappling with some of these issues as best it can within the limits of concepts, funds, and personnel. Here are several of the ways we are attempting to make our contribution.

During the past several months Resources for the Future has been examining systematically the raw-material and environmental consequences of several possible rates of population and economic growth in this country to the end of this century and beyond. The vast and complicated set of interrelationships among population, resources, and environment will always constitute a major concern for mankind. By means of statistical and mathematical analysis we are trying to specify the likely requirements for many kinds of resource commodities along with the kinds and amounts of pollutants and residual wastes that may be anticipated. Because of the uncertainties of new technology and changes in human behavior our results can be no more than approximations, but we hope that the range of possible error can be held within tolerable limits. In addition, special attention is being given to the consequences of growth (at different rates) on the use of land for agriculture and other purposes, on water resources in the major regions of the country, and on outdoor recreational resources.

Special work also is under way on the prospects for recycling more materials, hitherto discarded, back into production processes. Making use of both older and newer forms of technical analysis, this work should provide a comprehensive view of the population-resource-environment possibilities for the future. The effort thus far has been somewhat constrained in both time and geographic

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scope: we are looking only as far ahead as the year 2000 or in some instances 2020, and our focus is on the United States, although what is likely to happen elsewhere in the world has to be considered at least in a general way.

A principal value of this kind of exercise is that a framework is established within which significant changes of policy and action can be visualized and appraised. This work is being done in cooperation with the Commission on Population Growth and the American Future, but represents also a line of investigation that RFF had begun previously and expects to continue. One of our main purposes in this program of studies is to embrace both resource and economic development options and environmental consequences. The two are not separated in the design of the research, but linked throughout.

A second example of current RFF work in which both the developmental and the environmental factors are combined is provided by our energy resource program. In cooperation with the National Science Foundation we have drawn together a comprehensive statement of energy research needs. Concern in this country has risen rapidly in the last few years both with respect to meeting projected demands and in terms of reducing adverse effects on the environment. Several danger signs have recently appeared: the growth of energy consumption in the last few years has been faster than the growth of gross national product, reversing a long trend in the opposite direction; in recent years the increase in proved reserves of crude oil and especially natural gas in this country does not seem to be keeping pace consistently with growth in consumption of these products; the thermal efficiency of converting fossil fuels to electric energy seems now to be declining, running counter to a long-standing trend; the estimated costs of producing electric energy from nuclear sources are not coming down as rapidly as previously was expected; higher costs and uncertainties of supply of oil from some other parts of the world have not abated; and finally the costs of environmental protection and improvement, which will not be cheap, will have to be met.

These latter costs will be spread throughout the energy segment of the economy — from reclaiming strip-mine land and protecting ocean waters near offshore oil wells, to reducing air pollution from electric generating plants and heat discharge and radioactive contamination from nuclear plants. Many of the environmental damages associated with energy production and consumption are visible and important, but the more precise consequences are unknown, and the costs and other problems of avoiding them are not well understood. Possibilities for reducing the growth in energy use need to be studied and tested carefully as one way of ameliorating environmental damages. Running through all of these studies and speculations is the persistent theme of finding new patterns that reconcile economic growth with environmental protection.

A third example can be found in RFF's program of studies directed toward the better management of the pollutants and residual wastes spewed out by the American economy and by American consumers. This work is proceeding on a wide scale and is now near midstream. It includes theoretical and methodological analyses, investigations of various regions and polluting industries, and studies of the political and other processes by means of which the American people may choose the policies and institutions through which their environment can be improved. Much attention is being given to finding ways by which decisions affecting the environment can reflect fully and accurately environmental costs and benefits wherever they occur, as well as the more conventional costs and benefits resulting from the normal activities of production and consumption. Forms of regulation in the interests of environmental protection are being considered, along with incentive measures that would require private firms to take account of the environmental consequences of their activities; the full costs of prevention or correction could then be included in the prices of the products they sell.

At every point in this program an effort is being made to find what I called earlier a new synthesis of resource development and use with higher standards of environmental protection. This new factor of environmental protection has to be worked into the very fabric of the American economy and the economic behavior of individuals. Understanding how to do this constitutes a challenge of truly major proportions.

■ I could go on citing examples from our own work or from that of others. In our land use and management program, for example, we are trying to understand more deeply the processes through which rural land on the fringes of metropolitan areas are converted into urban uses. As anyone can observe, these processes are not working smoothly. As a result the cities are lurching into the countryside in a way that is sure to leave a residue of problems for a long time to come. With nearly all of the population growth in this country expected to occur in the suburban fringes over the next few decades — perhaps 80 to 100 million persons by the end of this century or shortly thereafter — it becomes a matter of highest importance that transportation and utility lines, industrial, commercial and residential developments, parks and open spaces be located and made to function so that the amenities of a clean and pleasant environment can be secured. Even if American planners and technicians are able to visualize desirable patterns for growth, will the governance of our metropolitan regions be adequate to the task of achieving them? RFF intends to move vigorously on this front in the years ahead, again searching for a new synthesis of development and environmental protection without which Americans will surely make a mess of things in future years.

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In all of these fields the role of public policy will be critical. Taxes, subsidies, regulatory actions, incentives for research and development, trade and investment measures taken by government, new modes of mediating disputes, political and institutional rearrangement — these are the instruments through which more profound changes can be guided and encouraged. Increasingly the responsibility of government at the various levels needs to be seen more clearly, the options for policy specified, and the consequences, both good and bad, laid out so that wise choices can be made. If resources viewed as commodities (either goods or services) are to be brought together with resources viewed as environment (land, water, and air) — if a new synthesis of development and protection is to be achieved in the 1970s — then it will be necessary to understand how public policy can be employed toward this end.

With this in mind, Resources for the Future expects during the next few years to place a new and added emphasis on what I would call the requirements for better resource and environmental policy. This will take the form of preparing rather pointed studies of problem situations that call for new policy treatment. For example, examination may be directed toward a resource and environmental issue in a particular geographic area, toward an existing set of policies thought to be inadequate, or toward some new policy that has been proposed. In each case the selection of the particular situation will be a discriminating one; our contribution will be to present briefly and carefully the background, an analysis of the critical factors, and an appraisal of the realistic alternatives for action. We shall draw heavily on our ongoing research, but would expect to present the policy studies I am describing here in a different and briefer format than the ordinary research book or monograph. A major theme of these policy background and analysis papers will surely be that of finding a new synthesis of resource and economic development on the one side and environmental protection and enhancement on the other.

TWO SPECIAL ARTICLES

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Man and His Environment: The Issues in Perspective

What is often called the environmental problem is in fact a complex of problems, which, though interrelated, have quite distinct characteristics. Some are localized nuisances; some may threaten all life on earth. Some are immediate; the ill effects of others may not be felt for a long time. The most promising ways of dealing with the different problems vary just as widely. A new RFF study seeks to present a broad, systematic view of the environmental situation and prospects insofar as this can be done with so many of the basic facts still unexplored or in dispute. The article that follows is adapted from the final chapter of Sterling Brubaker's book *To Live on Earth*, scheduled for publication early in 1972. [See page 80.]

A decade ago the doctrine that economic growth was the touchstone for dealing with most social problems was virtually unchallenged. Europe basked in its economic miracles, Japan loomed on the horizon as the economic success story it has since become. The United States elected a president committed to getting the country moving again, and we stood at the beginning of a hoped-for decade of development for poor countries. As we surveyed the prospects for the soaring sixties, no one mentioned the environment. Yet a scant ten years later earnest orators at Earth Day observances warned that mankind had entered an environmental and demographic crisis, that if we failed to gain control of it within the next ten years we were doomed to disaster. Has the situation changed so abruptly, or are we caught up in an ephemeral obsession?

There can be no doubt that the situation has indeed changed, not quite so abruptly as our perception of it, but rapidly and fundamentally. If we attribute the change chiefly to quickened economic and demographic growth following World War II and project the trend to the end of the century, we have the makings of a crisis. It will be difficult, in so short a period, to effect stopgap technical cures for the fast-deteriorating environment and even more difficult to alter basic human attitudes toward reproduction and economic achievement or to change our perception of man's role in nature. Such attitudes are the product of many centuries of development and, at least with respect to reproduc-

tion, may be rooted in the genetic makeup of the race. Our social institutions also are resistant to abrupt change. Yet if we can turn to account the institutions and motivations that we have, make rational application of science and technology to our near-term problems, and simultaneously move toward a set of values and aspirations consistent with long-range occupancy of the earth, we can hope to surmount the crisis.

The root cause of environmental problems is economic and demographic growth. We have compounded these problems by emphasizing incentives more appropriate to achieving growth than to improving environmental quality. But even with "wrong" incentives, development at lesser rates and lower magnitudes until quite recently did not impinge so strongly on natural systems and threaten to overwhelm them as it does now. Increasingly we exceed the capacity of natural systems to assimilate waste.

Recent rates of economic growth in many instances represent a doubling of output in the United States in less than twenty years. In the main, this has meant an equivalent increase in use of raw materials and of discharges to the environment. It is the nature of growth series that the absolute magnitudes represented build up rapidly. At the same time, this economic growth has been achieved through the more intensive application of science in processing and synthesizing materials, thereby introducing into the environment exotic materials that cannot be readily assimilated or whose effects on man and other species are ill-understood.

There is considerable disagreement over the extent to which economic growth, as distinct from population growth, is responsible for the problem. The dispute is not very useful. We know that with present per capita income, consumption patterns, and technical levels we already sorely burden the environment. Population alone has not been the principal villain. In the United States, economic growth has proceeded much faster than population, as reflected in our rising per capita standard, and while we have some of the world's most severe environmental problems, we are a country of only average density. In other developed countries economic growth also is the more dynamic element. In less-developed countries where population growth is usually faster, densities greater, and income growth sometimes slow, population growth is the stronger force.

However, population growth cannot be exonerated as a future source of difficulty in any country. It has a momentum that is hard to reverse. Although the transitional problems of stabilization are difficult, they must be faced at some point, and the advantages of stabilizing at a tolerable level are enormous. Whether we put the highest value on environment, income, other forms of life, or the maintenance of options, there is everything to be said for early restriction of population growth and hardly anything to be said for its continuance. When we consider that we cannot in good conscience insist upon the stabilization of incomes elsewhere at

levels below our own, the environmental implications of the increases become staggering. Whatever world problems may arise as a result of economic growth, it is a chilling thought that they will soon be doubled or quadrupled by population growth. The magnitude of the problem we must eventually deal with is closely tied to population.

Since a given output of goods can be obtained with different levels of discharge to the environment, we probably could modify our technology and produce something near our present output with considerably less environmental damage. Up to this point, both because of the reserve assimilative capacity of the natural system and because we have used it free of charge, we have had little incentive to minimize the burden imposed on the environment. Now that we recognize such a need, science plays a key role. One need is to modify technical processes so as to minimize harmful discharges. Another is to improve our understanding so that we can identify and forecast damages and other effects of these discharges.

It is surprising to discover how little we know of the effects of man's activities on larger natural systems, on specific life communities, and on the health of man himself. This ignorance begins with a lack of information on the character and volume of many of our industrial discharges. It extends in particular to our understanding of such large systems as the dynamics of the atmosphere and the oceans. We have only a tenuous grasp of the movement of plant nutrients and their migration into water. The disposition of pesticides is poorly understood, as are some of their effects on life. The same goes for radioactivity. We are dependent on science to describe the nature and extent of damage and to identify problems in advance, so that society can judge what risks it will take. So far we have avoided disaster, but we need a more comprehensive scientific warning system if we are to have reasonable future assurance.

So long as we choose economic and demographic growth, and so long thereafter as we aspire to improvement in environmental standards, there will be a place for technology in elaborating the techniques of abating pollution. We have hardly begun. Processes can be designed to save materials, to recover or recycle usable materials, and to neutralize those that must be discharged. Such possibilities are strongest in industry, and with some exceptions, in agriculture. The control of materials is more difficult once they are dispersed into the hands of consumers, but we can expect improvements in methods of collection, treatment, and recovery of such residuals as solid wastes, sewage, and auto bodies. In some cases, the pace of technical solutions will be quickened if the manufacturer is made to assume greater responsibility for

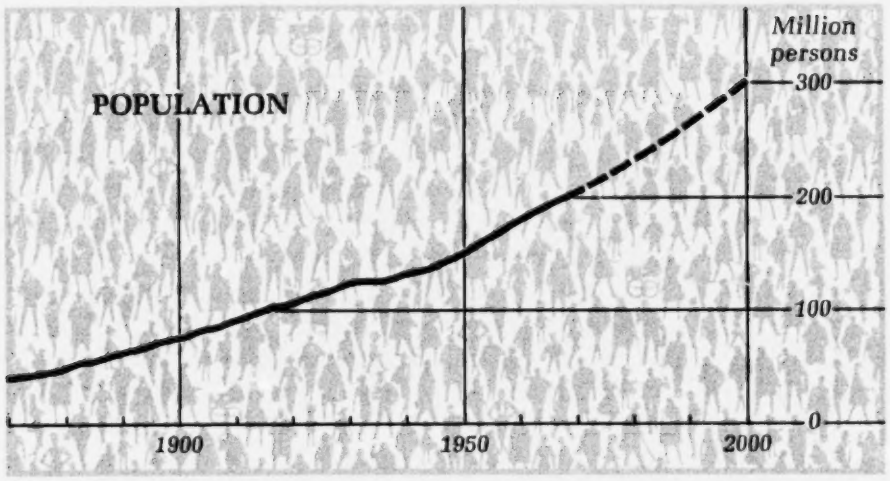
producing more durable and less noxious products, or to attend to their consequences.

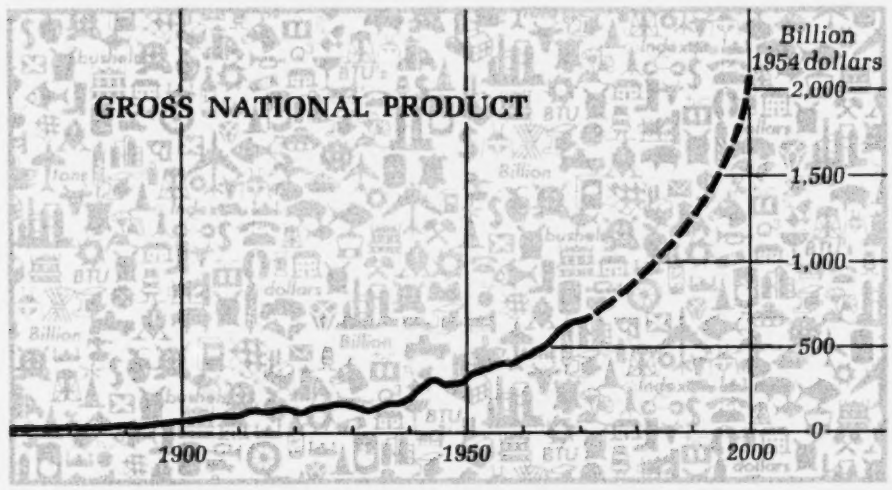
Many of our more acute or immediate environmental problems appear amenable to technical solutions. Much of the burden that wastes cast upon water can be traced to a few sources — inadequate sewage treatment, a few food processing industries, and pulp and paper mills. Concentrated action in these areas would make a great difference. Excessive nutrients that lower water quality also derive from cattle feedlots, and perhaps from fertilizer use in some cases. All but the latter could be dealt with readily. We have a host of problems connected with the use of energy, especially in the combustion of fuels. Although they are not easily solved, we can go far toward mitigating the effects. Our failure to do so stems from inertia or unwillingness to pay the cost.

We cannot avoid the cost. If we do not pay it in the cost of products, we pay it in damage to health and amenity. Wider appreciation of this fact will support the kind of measures needed to ensure that technical solutions are found. A most urgent need is to provide incentives. Technical solutions will lag as long as we allow free access to our common environmental property. If society is made aware of environmental costs and has the means for expressing its wishes, then regulation and incentives can be used to keep pollution within limits. We can establish standards of air and water quality, rationing the portion of the environment's assimilative capacity that we choose to employ and allowing product price to reflect the cost of environmental protection.

The capacity of an airshed or watershed to absorb wastes varies with a number of conditions. If we aim to maintain air and water quality within set limits, we have a management task to perform. It may involve the augmentation of capacity, the scheduling of use, or other measures for which systems management techniques are appropriate. When technical advances, incentives, and management are effectively coordinated, we should be able to increase the flow of useful goods from the economy without equivalent increase in environmental damage. Moreover, we can aspire to do this at moderate cost.

■ But if economic and demographic growth is extended far enough into the future, our environmental problem is greatly magnified. At some stage it may overwhelm the technical and managerial measures from which we have just derived interim hope. Moreover, the availability of resources, which has not been considered a serious short-term problem, cannot be so treated if we project far enough into the future. The earth is finite and growth must stop somewhere, whether arrested first by resource limitations or environmental tolerances. Massive applications of energy permit more complete recycling of materials, and can enable us to stave off these limits, but not forever.





Population and economic activity — root causes of nearly all environmental problems — have grown impressively in the United States over the past century and will go much higher in the next three decades if present trends continue.

Rather than dream of technological utopias that promise ever more goods, perhaps we should take human needs as a starting point and consider how we can cut the cloth to fit them. Several possibilities are open. We could reduce pressure on the environment by restraining income growth, although it is hard to see how this could be attempted without major income redistribution. Much could be done through improved design and durability of goods to alter patterns of consumption so as to reduce the required volume of materials. Or we could stress nonmaterial forms of consumption — education, sport, music, and theater, for example. Alas, much travel might have to be excluded from the list because of its high use of energy. Most optimistically, there is the chance that income growth — if properly channeled in terms of consumption patterns and investment in environmental technology — can

be consistent both with increased consumption and improved environmental quality. The chance improves if we do not multiply the problem by population increase.

On a world scale the United States has set an example of economic performance that, even at our present level, will be hard for others to match for generations, if ever. We in this country might succeed in controlling our own effluents and in producing and recycling the resources we need, only to find that less-developed countries aspiring to similar economic standards are willing to take environmental risks of world consequence in order to achieve them. We would have no moral basis to deny them.

During the decades ahead while we grope for possibly different values we must assume that some economic and demographic growth will occur, and we should make the best use of our scientific and institutional resources to contain its environmental impact. It will be helpful if we keep our problems in perspective, recognizing that some, while annoying and immediate, do not threaten disaster, while others, less obvious in our daily life, must be carefully watched lest they bring catastrophic damage. We have no single environmental problem but a host of them, and we have a number of means of coping with them. Without diverting our concern about the long term, we must learn to manage the present.

Sorting out the priorities and devising the best means of dealing with each will be a complex task. In ascending order of gravity our environmental problems can be ranked in this order: (1) amenity considerations like litter, noise, and appearance of cities and countryside; (2) threats to human health; (3) threats to human genetics and reproduction; and (4) effects on ecological systems that would threaten the earth's capacity to support life. Some of the problems are local; others range in scope on up to global. The remedies that seem appropriate to each problem could involve one or more of a wide variety of economic, institutional, and technological approaches.

Many of the less grave threats to the amenities or health seem to annoy the public the most, and are sure to receive concentrated attention. Generally speaking, their effects tend to be local and they can be managed at tolerable cost through technological or institutional adjustments in the near term. However, this does not justify complacency, for it is uncertain that we will apply ourselves to achieve the desired results.

The possible consequences of the graver threats tend to be deferred in time and enlarged in scope, so that the appropriate administrative unit for dealing with them becomes larger and the remedies are more likely to depend on changes in attitudes and values. Sensible strategy will give greater weight to the graver threats, for we can take few chances with disaster.

For some purposes, the classification of problems into short-term and long-term is useful. Short-term problems are those that

already (or will within a generation or so) require remedial action to avert unacceptable congestion or to avoid permanent damage. Problems of this sort fall within a planning horizon with which we are accustomed to deal. Decisions are made by those who will bear the consequences. Long-range problems strain our conventional decision apparatus. We can ensure a future for subsequent generations only if we develop an essentially conservationist view of the earth. The two periods are not entirely separate. They are linked because many of the actions taken today will condition the possibilities of tomorrow.

Most health and amenity considerations are one-generation problems. We may pass on a technology that imposes burdens on our heirs, but they have the same options as we to escape their dilemma. We are left to our own standards of taste and to our willingness to pay for higher standards; we can hardly be expected to consider only the remote future. In fact, we may best serve the future by improving our science, technology, and institutions so as to allow future generations to deal with these problems in their own way.

The presence of irreversibilities changes the picture, even for health and amenity considerations, because then future generations do have a stake in our actions. We may still choose to proceed with caution. But when dealing with threats to human genetics or the life-support system we cannot responsibly proceed in the face of such uncertainty. At this point we must invoke another standard — one that holds the life-support system inviolate above all else. The most difficult problem is how to evaluate the threat — its nature, extent, probability, threshold, and the like.

Over the long run, institutions respond to changes in social values. But they always lag, and early attention must be given to the technical problems of designing social means for dealing with our problems. The potentially valuable role of the market in allocating assimilative capacity is obvious, and enlarged management authorities capable of dealing with a whole range of problems also offer interesting possibilities. Both instruments need further elaboration. Our experience with them is limited, and our hopes for their effectiveness could be disappointed.

Whatever the instruments used, the framework of social goals will be set somewhat independently. The process of arriving at the public's wishes is difficult. We all want a clean and healthy environment but disagree on who gives up what to get how much of it. The fact that the environment is held in common requires that social choices be made. Economic criteria give us important dimensions of this choice, namely, the cost of the technical alternatives that scientists and engineers cast up, and comparisons between measurable costs and benefits, but in the end we fall back on political processes for arriving at policy. The level at which decisions should be made, the designing of political units of proper scope, the procedures for framing issues, the mechanics

of bargaining to arrive at policy — all are part of the process.

Man's attitude toward his role in the scheme of things is fundamental to many questions. In particular, the extent to which we are prepared to occupy and transform the earth hinges on this. We probably can survive (although this is not certain) in a thoroughly synthetic environment in which most natural systems have been destroyed. If we take this path we venture into an unknown far greater than that which lay ahead of any quest of the past, for we take all of life with us and there is no return. It is hard to see that the gain could be worth the risk. If we are not to go that route step by step, then we must consciously and soon restrict our range.

Our prospect viewed from the standpoint of our possibilities is reasonably optimistic. We can improve our technology and management so as to eliminate much environmental damage and we can continue to generate a social dividend, part of which may be devoted to environmental preservation. By adjustments of consumption patterns, income, and numbers we can aspire to permanent occupancy of our planet.

The question is whether we have the will and the foresight to take all the necessary measures in time — to reform our individual thinking and to organize ourselves at appropriate levels to deal with our problems. We must truly learn to govern ourselves if we are to survive. The task calls for the most arduous personal and social discipline. While some current tendencies toward a simpler life would reduce the environmental burden, they often are accompanied by anti-rational attitudes and a mistrust for organization of the sort needed to manage a complex system. A new set of values is needed in which the commitment to environmental quality is wedded to personal values and life styles that do not negate our progress but seek rather to make it serve a new vision.

While a few technocrats may thrill to the vision of a far more numerous population living in a highly synthetic world, most of us cannot so readily abandon the natural system in which the race was formed. If it is our aim to come to terms with that system and occupy a role within it, then we must contemplate early limitation of our numbers and devise a technology that stringently limits environmental burden. While this may allow for some income growth as our understanding improves, it gives precedence to the preservation of major elements of the natural system. It implies a kind of responsibility which is the absolute antithesis of the query, "What did posterity ever do for me?"

As a setting for human life such a prospect promises to be far more satisfying than one in which man barely manages to survive in a mad race between technology and population. One cannot know whether we will accomplish this shift. Much depends on how we in the United States spend our scientific and social capital and momentum. The situation does not call for despair, but we urgently need sustained intelligent concern and action.

The Scrambled Pattern of Suburban Land Conversion

Urbanization in the United States has come more and more to mean suburbanization. A growing proportion of an increasing total population lives in metropolitan areas, but the older core areas have not kept pace; indeed, some have actually lost population in recent years as people have moved out into surrounding territory to find more room. The resulting pattern of land use has few unqualified admirers, and has aggravated some of the most pressing social, economic, and political problems of our times. In a recent RFF study Marion Clawson concludes that many of the difficulties grow out of the processes by which rural land is converted to suburban uses; explores their nature and effects; and offers some suggestions for improvement. The article that follows is based upon his new book, *Suburban Land Conversion in the United States: An Economic and Governmental Process.*

The transformation of the United States from a rural to an urban nation is a familiar story. When the first census was taken in 1790 about 5 percent of a total population of around 4 million lived in "cities" of more than 2,500. Today nearly three-quarters of a population of over 200 million is urban, and the shift is continuing. Not so widely recognized, perhaps, though also of long standing, is the rising share of the suburbs in this growth. The latter trend has been statistically obscured by the fact that over the years most of the older cities have been extending their legal boundaries. By now slightly more than half of the population classified as urban lives beyond the central cities, and many industrial plants and retail businesses have been moving out to the suburbs along with the people.

The process of suburbanization is the most important change in land use that is taking place in this country today. The suburban fringe, which in most cases extends a few miles beyond the actually settled areas, is where the action is — land transfers, conversion of land from one use to another, and marked changes in land prices.

Some of the results of all this activity are plain for all to see — millions of new homes, some attractive, some drab; garish strip development strung far out along main highways; vacant lots and some larger tracts passed over in the outward thrust; new shop-

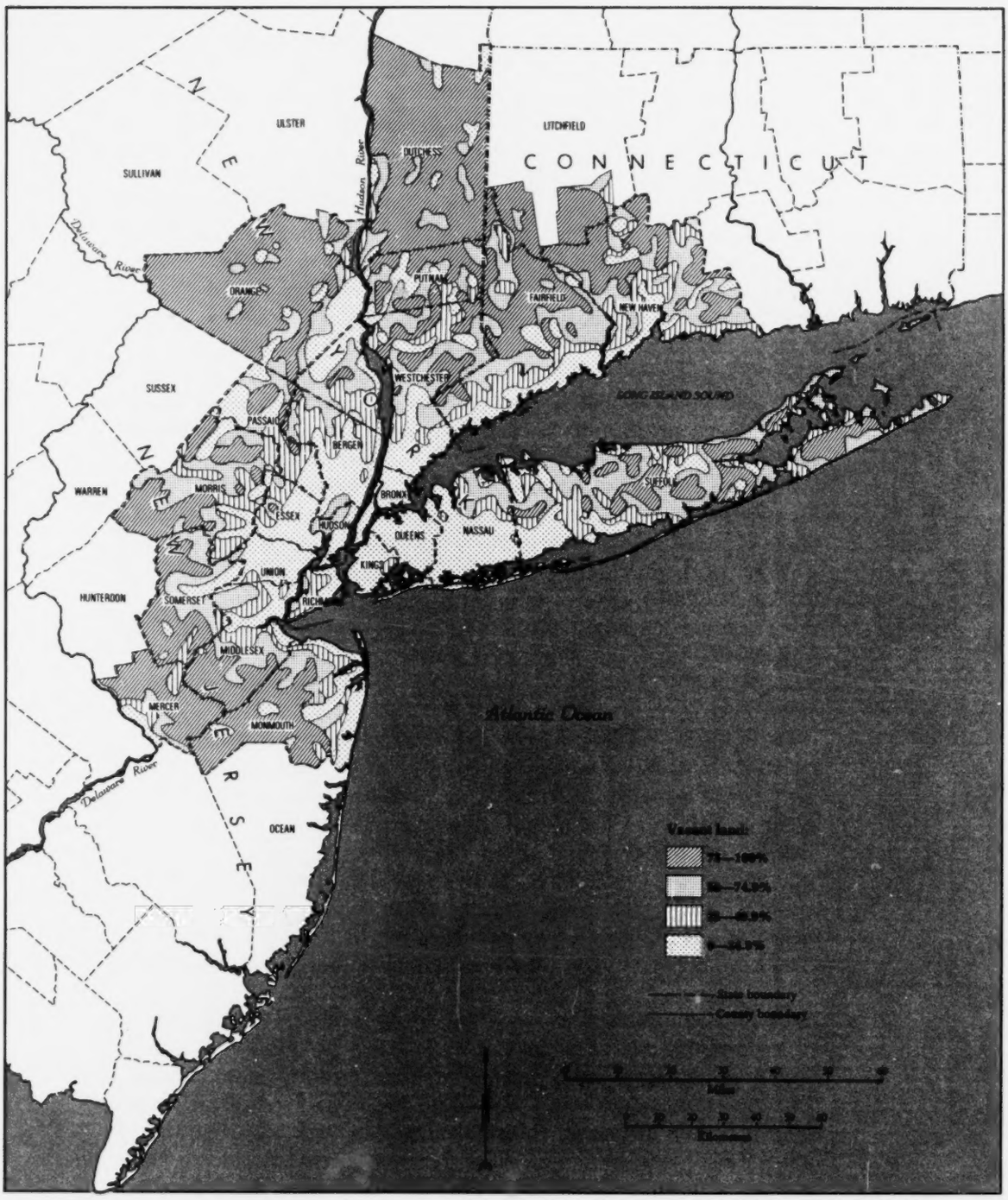
ping centers and industrial parks; and creeping traffic with its reek of engine fumes during morning and evening rush hours.

Other results are less visible. Generally speaking, the cost of buying and servicing a home in the suburbs is unnecessarily high. This has had its effects on the kinds of people who live there and on their patterns of family and community life.

Perhaps most important of all are the effects of the suburbanization process upon the inner cities. Although the suburbs drain off many of the long-time inhabitants of the core areas along with the more affluent newcomers to metropolis, suburban houses are beyond the financial reach of poorer families, which usually include most of the blacks and other minority groups. This barrier is often reinforced by zoning requirements for large lots and expensive houses. Thus for many inner city families the suburbs are more like walls to hem them in than avenues to beckon them out. This is one of the main reasons why tax bases in the central cities erode; the support of education, health, and other services declines; and ghettos develop. Many of our most pressing national problems — public welfare, racial tension, crime, and violence — are primarily problems of the city. The present pattern of suburban growth, though by no means the only cause of any of these difficulties, has contributed to all of them. This pattern, in turn, is largely shaped by the actual processes by which land is converted to suburban uses.

■ At the beginning of the chain is the farmer (or other owner who held land for purely rural purposes). Contrary to common belief, he is seldom on the scene when the active phase of land conversion begins. Usually he has sold out — at a profit — some years before to a land speculator. The speculator (the term is not used here in any pejorative sense) may be a purposeful land assembler or merely someone with faith in future land values and access to capital. Next enters the developer, who does more than anyone else to put his stamp on the suburb-to-be. He estimates the demand for the kind of housing he plans to build, sometimes on the basis of careful study, sometimes on hunch; acquires the land; and decides on the lot and street layout. (To further complicate the picture, the developer does not have to be a single person or firm; his functions often are divided among brokers, site planners, builders, and other specialized operators.) Last comes the suburban homebuyer or apartment renter whose choices and willingness to spend are the fuel that makes the whole process go.

The whole process of suburban expansion requires substantial amounts of capital. Both developers and final buyers depend heavily on loans, and the attitudes of lenders toward particular areas, types of housing, and individual developers strongly influence many development decisions. Most lenders are interested above all in "financial soundness" which they usually measure



As urban development spreads outward from the older city center it jumps over many tracts of vacant land, some of which are wholly or partially "infilled" by later development. The extent of this bypassing is one measure of land use examined in Suburban Land Conversion *(see page 49). The map is adapted from one appearing in the Tri-State Transportation Commission's 1967 report,* Measure of a Region.

by extremely conservative standards. In general, the pursuit of soundness has operated to reinforce tendencies toward suburban segregation by income and consequently race.

Although suburbanization comes about mainly through a network of private decisions and transactions, public agencies play an important part by providing the framework within which development takes place and often by intervening more actively. Federal tax laws, credit programs, and aid to highway building, for instance, have generally stimulated suburban growth and influenced its directions. States, and in some areas regional authorities, also are involved, though to a lesser degree. By far the most active government participation comes at the local level. In addition to levying taxes, city and county governments exercise a variety of powers, such as planning, zoning, subdivision regulation, and housing codes. Some or all of these powers have been used vigorously in some localities, less so in others. Some decisions of local governments, or of boards established by them, have been influenced by pressures from interested parties. Zoning, upon which much reliance has been placed as a means of imposing order upon the suburbanization process, has generally proved a weak reed, especially where it has been applied in an ad hoc manner without regard to a long-range master plan, if indeed there is one. The nominal planners often are not the real planners, fragments of that function having been usurped by sewer builders, transportation authorities, and other operating units of government.

In its barest outline, this is the system, if such it can be called, by which suburbanization has gone forward. The principal actors are private firms or individuals, each seeking his own gain. Public agencies influence the process, but cannot control it; their efforts are not coordinated and often they work at cross-purposes. No one person or organization is responsible for the whole job and its final results. There are indeed general planning organizations interested in the long-range development of a city or metropolitan area but almost always they lack means to carry out their ideas.

■ The whole haphazard process has brought mixed results. On the plus side, millions of suburban homes and hundreds of shopping centers have been built during the past twenty years. Many of the houses and apartments are comfortable and many of the new neighborhoods pleasant. Schools, churches, and other community institutions have been developed. The energy and ingenuity shown by both private and public participants in expanding the suburbs has given the movement a vitality that is clearly a national asset.

On the other hand, there are serious disadvantages. Costs have been too high, mainly because of sharp and continuing increases in land prices although other forces have been at work. In a 1968 RFF study A. Allan Schmid, on the basis of the incomplete data he was able to assemble, estimated that an acre worth $300 as

farmland would be worth $10,072 as an improved lot, an increase in land value of $3,440 when the cost of the developer's improvements is deducted. Even more important than the excessive costs of the kinds of housing actually produced is the fact that land prices have inhibited the building of more modest housing. Houses built on expensive lots had also to be expensive if the price for the whole package was to seem reasonable. This trend has been strengthened by the desire of many suburban units of government to make the cost of new housing beyond the reach of lower-income people.

The suburbanization process has been wasteful of land. Large and small tracts are leapfrogged in the hit-or-miss spread of development. Even in areas officially classified as urbanized perhaps 30 percent of the land still is not in urban uses. (This estimate does not include land publicly held for streets, recreation, or open space, which certainly should be considered as "used.") The resulting urban sprawl is not only often unsightly but also costly to suburban residents. Scatteration of public services like water and gas and electricity involves costs that probably average $150 a year per family above what would be incurred in reasonably compact settlements. And this sum does not include the taxpayers' share of added costs of roads and greater dependence on private automobiles and the accompanying rise in air pollution.

Finally, programs like air pollution control and development of coordinated regional transportation, which must be undertaken on a metropolitan scale, have been made much more difficult by the fragmentation of government in metropolitan areas. Each suburban community wants to be "independent" in some sense. The physical and economic city has outgrown the legal and political city. Although the suburban land conversion process has not been wholly responsible for this situation, it has done much to bring it about.

It is clear that processes of suburban land conversion have failed to meet the needs of a very large segment of the population and have generally been inefficient and overcostly for all concerned. Any real improvement will call for major changes in the present system. Some of the possibilities are noted briefly below.

Many of them consist in doing better what already is being done ineffectively. Planning of land use and other aspects of suburban growth could be strengthened by more precise estimates of the benefits and costs of a particular plan and by estimates of their incidence: who gains, who loses, and by how much? Also, while a plan is being formulated, planners might work more closely with the full range of interested private groups and not hold as aloof from political processes as in the past. Authority to zone should require that a responsible unit of local government first adopt and then pay attention to a general land use plan. In addition there should be provision for appeals from local zoning decisions to regional levels of government. Finally, inordinate

pressure upon zoning authorities can be prevented only if some means is found to avoid windfall gains.

Extension of public improvements such as roads and sewer and water lines, and the pricing of such services, should be in accordance with a general plan of development. This can be done only if the general governing body of a county or some other area gains or regains control over specialized service agencies.

Improvement of the functioning of the suburban land market first of all will require better information on land transactions. Among newer measures that would help is a change in the federal income tax laws to transfer increases in raw land prices from the capital gains to the ordinary income category. The federal tax rules under which new owners of rental properties can repeat the process of charging off depreciation could be changed so as to permit full depreciation allowances for a property to be made only once. Local real estate taxes could be modified to shift more of the burden on land and away from improvements. Assessments on idle land could be adjusted more quickly to changes in market prices and in rezoning. All of these changes would help reduce inordinate profits from land speculation.

Some units of local government are too small to function effectively. Steps could be taken to abolish the very smallest units and to encourage larger units on a metropolis-wide scale. Such changes would also promote a more useful and equitable sharing of revenues and costs.

All these improvements, and others like them, would make the suburban land market and the conversion process function better. Yet it is doubtful that they would be sufficient. If we really wish to cure the major deficiencies of suburbanization, public purchase of land must be initiated and carried out on an adequate scale. The usefulness of advance public buying of land for public purposes already is well established. What is suggested here is extensive public purchase of land to be later sold or leased under carefully specified terms to private developers for residential, commercial, or industrial purposes. Whether by negotiation or condemnation under the right of eminent domain, the land would be bought at current market prices. The subsequent sale or lease of the property could specify not only the uses to which the land was to be put, but many other conditions, including design. Because the successful bidder would enter the contract by his free choice, there would be no legal reason why the terms of sale should not specify much more relating to future land use than the courts have upheld as reasonable in zoning cases. Although a maximum price for the public lands sold would be one objective, it need not be the controlling one. The conditions of sale could provide that the developer offer the lots and houses at not more than a stipulated price. This may be the only way in which suburban housing can be made available to lower-income families, at least for some years.

- Some combination of improved and new methods could do much to make the suburbanization process more orderly and efficient and put it more in line with pressing social needs. Naturally, it would not bring Utopia; for one thing it could only alleviate the problem of housing for the poor, which cannot be really dealt with unless and until the great gap between lower and upper levels is narrowed through a broad national effort. Neither will the suggested remedies be easy; but they do seem feasible if the American people are willing to put enough thought and effort into them. And their realization would bring benefits not only to the suburbs and central cities, but to the whole country.

THE YEAR'S WORK IN REVIEW

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A Summary of the Year

Population, a major element in most problems of environmental quality and natural resource adequacy, received increasingly explicit attention in RFF's work during the 1971 program year. Activity in Latin America was expanded when liaison was established with a center for regional development and planning in Brazil. Research into questions of current public resource policy was expanded, some of it supported by public or nonprofit private agencies that had asked RFF to undertake studies in areas of our special interest and competence. A broad study for general readers on man's relation to his physical environment was completed. Several long-term, comprehensive studies were published or brought near to publication.

- At the request of the President's Commission on Population Growth and the American Future, an inquiry into the probable future relationships among population growth, economic growth, and environmental quality in the United States was begun and largely completed during the program year. The project is closely related to RFF's environmental quality program and to a planned updating of our 1963 study bearing on resource adequacy up to the year 2000, both of which are noted below. Late in the program year RFF received a $20,000 grant from the General Service Foundation of St. Paul, Minnesota, to examine the possibilities of extending the population-environment study to an exploration of worldwide prospects.

- RFF's two contributions to the series of Middle Eastern studies, conducted in cooperation with the Rand Corporation, were published during the program year. One dealt with the area's agricultural potential and the other with its petroleum resources. A report on possibilities for land and water development in the Lower Mekong Basin, made late in the 1970 year for the World Bank, was published for general distribution. The cooperative program of teaching and research in Latin America, already established in Mexico and Argentina, was extended with the appoint-

ment of an RFF representative in Brazil. The longer-standing collaboration with the Latin American Institute for Economic and Social Planning, at Santiago, Chile, was continued. A study of water management in the arid regions of nothern Mexico was completed and is being prepared for publication in English and Spanish. Studies of foreign investment in Latin American forest industries and of problems of rural underemployment and agricultural stagnation were begun.

- The residuals management model that is central to much of the program of research into environmental quality was further developed and extended during the past year and preliminary work was begun toward applying the model to an actual area — the lower Delaware Valley. Progress was made in supporting studies of residuals generation in specific industries, and one of them — wool processing — was completed. A general inquiry into the problems and possibilities of recycling was begun, and work on a case study was continued. Research into institutional aspects of residuals management was expanded to include new studies of public responses to various methods of pollution abatement. Further support was given to continuing study of the relation of air pollution to human health. At the theoretical level, research was begun into the desirability and feasibility of supplementing the accepted indicators of economic levels — mainly gross national product — with indicators of environmental quality; and a monograph on the economics of environmental quality from a materials-balance approach was published. Also published during the year was a set of regional projections of water supply and demand in the United States in relation to quality, quantity, and economic growth.

- Research into problems of natural environments — wilderness, backcountry, and other unspoiled areas — was carried forward in a number of projects relating to both the allocation and management of such land and water resources. Current results of several of these inquiries were presented and discussed at a workshop conference in August. At the close of the year the papers were being revised on the basis of workshop discussions. A study of the ecology of wildlife populations, with special regard to management alternatives, was begun. A monograph on competition in the wetlands of the Midwest between use for agricultural production and use as wildlife habitat was published during the year.

- A broad study of the economic and political aspects of suburban land conversion in the United States was published during the program year. A parallel study for Great Britain, made with RFF support, was completed and being prepared for publication in that country. Both studies provided background for a comparative analysis of problems of urban growth in the two countries, which

was near completion at the close of the year. A case study of methods of evaluating flood control policies, based on data from the Po Valley in Italy, was completed. A study of the biological, economic, and public policy aspects of wildlife management was begun. Two water management studies were published, one dealing with interbasin transfers and the other with the relationship between drought hazards and urban water supply planning.

- A study of research needs in the broad area of energy policy, begun early in the program year at the request of the National Science Foundation, was in draft form at the year's end and was formally submitted in October. University scholars and industry and government officials were principal speakers in April at an RFF Forum on energy, economic growth, and the environment. The papers, as revised by their authors, are being prepared for publication. Studies of the structure of mineral industries in many countries and of the problems of mineral-exporting countries were begun. A comprehensive volume on long-term trends in energy consumption, production, and international trade since the 1920s was scheduled for publication before the end of 1971. Published during the program year were studies of petroleum conservation in the United States, foreign investment in the petroleum and mineral industries, and changes in the world market for iron ore since 1950.

- At a five-day conference in Glasgow, conducted jointly by RFF and the University of Glasgow, British and American scholars explored the theories, methods, and effectiveness of national policies for urban and regional development as they have been carried out in the two countries. The conference papers will be published in two special issues of the international journal *Urban Studies*. A number of the papers being written for the Commission on Governance of Metropolitan Regions, organized in the 1970 program year under RFF sponsorship, were completed. Ten of them are being prepared for publication in three small volumes, with further volumes in the series expected. Studies of the federal role in regional development and of the concept of social learning as a key to understanding processes of economic and social development were published during the year, and a study of the structure of urban communities was sent to press.

- A study of present and prospective environmental problems, designed for general readers and based primarily on the results of RFF research, was completed and sent to press at the close of the program year. Publication of a cloth edition is set for early 1972, with a paperback edition to follow. An updating of RFF's 1963 study of natural resource adequacy to the year 2000 was undertaken. Draft materials for a shorter version of the original volume were in hand at the close of the year. The work also

will feed into the current population-environment study noted above.

- Twenty grants totaling $175,000 were made during the year. Eleven fellowships amounting to $43,750 were awarded to doctoral candidates whose dissertations will deal with social science aspects of natural resource and environmental problems. Fourteen theses by earlier recipients of fellowships were completed. Seventeen books were published and eight others sent to press as part of RFF's own publication program. Seven manuscripts resulting from research supported partly or wholly by RFF were published under the sponsorship of seven other institutions.

Quality of the Environment

Nearly all the research of Resources for the Future bears in some degree upon questions of the environment. The program devoted exclusively to quality of the environment addresses such problems directly. The work is premised upon the belief that the many kinds of pollution and the possibilities for abating them are so strongly interrelated that a comprehensive approach is needed to understand environmental threats and point the way toward remedial programs and policies. Most of the work concerns the management of the residuals of high-level production and consumption. An allied but autonomous RFF program deals with the somewhat specialized problems of natural environments such as wilderness and back country.

REGIONAL RESIDUALS MANAGEMENT

Central to work in this area is the development of a model, or articulated system of relationships, by which the probable direct effects and side-effects of various assumed situations, as well as policies and management strategies, can be calculated. During the past year the model has been developed to a point at which it can soon be applied in an illustrative way to a specific area.

The model is designed to deal simultaneously with energy and material residuals, including the three forms of the latter — airborne, waterborne, and solid — by allowing consideration of physical trade-offs among them in the processes of production, residuals handling, and consumption. It also permits consideration of changes within production processes, such as variations that would affect, for example, the quality of raw material inputs, modifications of product outputs, and variations in the degree of reuse of residuals.

The residuals management model consists of four submodels: (1) a linear interindustry model permitting choices among assumed production processes and residuals modification and discharge activities; (2) a set of ecological models relating the movement and

degradation of residuals discharged into the environment to their impacts on specific plant and animal groups; (3) a set of receptor damage functions relating the concentrations of residuals, or impacts on species, to the costs and damages incurred by man; and (4) a model of political choice processes, which permits the aggregation of political preferences with respect to environmental and other public choice issues. Early versions of the model were devised by Clifford Russell and Walter Spofford, who continue to take a leading part in improving the model as well as in applying it to a case area.

One of two significant improvements made in the model during the past year replaces some of the earlier environmental diffusion calculations with ecological relationships. Robert Kelly, a recent Ph.D. in ecology from the University of North Carolina, is working with the RFF staff to develop models for relating residuals discharges to impacts on plant and animal groups (submodel 2). Although the more conventional approach of analyzing the diffusion of materials in air and water yields necessary information, it cannot bridge the gap between conditions in the physical and chemical environment and impacts on life processes. Kelly is applying ecological principles to a large-scale resources management problem that is part of the Delaware Valley project described below.

The second improvement in the overall model takes into account public choices and public choice mechanisms (submodel 4), concerning, for example, distribution of benefits from improved environmental conditions and allocation of the costs of achieving these conditions. Edwin Haefele is developing the submodel so that it can provide information about this set of problems in the context not only of alternative management plans but also of the preferences of the citizens affected. Elizabeth Reid is assisting with data collection and analysis.

While these improvements and modifications are taking place, a start has been made in applying the residuals management model to a specific region — the lower Delaware Valley. An RFF research team is already engaged in data collection and analysis. Several government agencies have assisted in this effort, especially the Delaware River Basin Commission, the Delaware Valley Regional Planning Commission, and the National Center for Air Pollution Control, by supplying data and components for the overall model. Other local groups in the Delaware Valley have also been helpful. This case study will provide the means for testing hypotheses about explicit interdependencies among different types of residuals. It will also provide realistic analyses of a number of policy alternatives and of the problem of presenting useful information to policy makers and the public. It may in addition provide the kernel of a quantitative model that will have continuing utility for the analysis of policy and operations with regard to residuals management in the Delaware Valley.

RFF is contributing to the development of a companion case study in Sweden. In this connection, Karl-Göran Mäler of the Stockholm School of Economics spent some six months of the year at RFF as a temporary staff member. Part of his activities involved consulting with the quality of the environment group and learning about the modeling efforts here. His other activities are described below.

ASSOCIATED STUDIES

A number of studies are being undertaken to provide data that will be useful not only to the regional residuals management model, but also in the analysis of particular problems relating to environmental management and policy. These projects include industry studies and others dealing with damages from residuals discharge, recycling of residuals, perception of the environment, and environmental management institutions.

— RFF's industry studies attempt to identify technologies that are available for residuals control and to determine the cost of controlling residuals in varying degrees. These studies are innovative both in their simultaneous consideration of all residuals streams through using concepts of material and energy balances, and in their consideration of a wide variety of alternative means of reducing residuals. These include changes in the quality of inputs, in industrial processes, and in the types of outputs as well as changes in residuals treatment after generation. The last has often been the exclusive focus of previous studies of residuals control costs. Blair Bower is giving general direction to these studies and is currently working on two of them — pulp and paper, in which George Löf and William Hearon, a private consultant, have cooperated; and canning, on which Norman Olson of the National Canners Association is working under a 1971 research agreement. Clifford Russell and William Vaughan are conducting studies of the petroleum refining and steel industries. In June, Thomas Cochran, formerly of the Litton Scientific Support Laboratory at Fort Ord, California, joined the RFF staff to study residuals management in the nuclear energy industry.

During the year RFF made a grant of $10,700 to Northwestern University where Leslie L. Roos, Jr., assistant professor of political science, will study the response of industry to environmental constraints. Roos will examine a group of industries, using statistical methods to test different theories of organizational and innovative behavior. Results of the study should be helpful in assessing how industry is likely to respond if attempts to protect the environment lead to governmental constraints on industry behavior.

— A grant of $11,500 was made to Carnegie-Mellon University in continuing support of studies of the effects of air pollution on human health, which are being conducted by Lester B. Lave, associate professor of economics. He will analyze statistical associations between data on mortality and the incidence of disease and data on air quality and numerous other economic, social, and demographic variables that may be connected with morbidity and mortality. The analysis is expected to contribute to RFF's set of studies dealing with damages resulting from environmental deterioration.

— Several studies of the recycling of residual materials are under way. Focusing on the secondary materials industries, RFF's objective is to identify opportunities for recycling and evaluate their prospective usefulness when (for example, through various types of restrictions or effluent taxes) the social costs of disposing of residual materials may be felt by industry and consumers. Thomas Quimby is continuing his study of paper recycling, using the Washington, D.C., metropolitan area as a case situation. During the year the International Research and Technology Corporation completed a report dealing with the wool-reprocessing industry. The analysis, which has been done under a research agreement with RFF, will be used by the staff in connection with RFF's broader recycling studies.

Under another research agreement, Frank Smith of the Center for Environment and Man is preparing a general report on the economics and prospects of recycling. It will include a survey of recycling industries to determine which ones offer potentials for further useful study. At the end of the year Talbot Page, a recent Ph.D. from Cornell University, joined the RFF staff to study how specific incentives affect the reuse of the materials in today's economy. In addition to effluent controls and taxes, such influences as depletion allowances, possible freight-rate discrimination, and labeling requirements will be examined.

— During the year a grant of $19,500 was made to the University of Toronto, under which Ian Burton, professor of geography, will study the public response to air pollution control measures in the United Kingdom. In that country the Clean Air Act of 1956 permits local government authorities to take strong action against air pollution. Burton and his collaborators will attempt to find out why the response to this Act has been so variable from place to place, and how local reactions are related to public understanding of the nature of the problem.

— When Lyle E. Craine of the University of Michigan completed his study of water management innovations in England (published by RFF in 1969), the River Basin Authorities created under the 1963 Water Resources Act had just come into existence, and it

was too soon to assess their actual performance as against their expected performance. During the year RFF made a grant of $5,000 to the University of Victoria (British Columbia) for a further study of these institutions, which have now been functioning long enough to warrant such an assessment. The research will be conducted by Derrick Sewell, professor of economics and geography.

RESIDUALS MANAGEMENT: THEORETICAL AND POLICY STUDIES

In addition to the development of the overall model and the detailed microeconomic studies of residuals management described above, RFF is sponsoring efforts to improve economic theory in a way that will permit it to incorporate environmental considerations in a more realistic and useful manner than it now does. Work is also going forward on some of the broader national and international issues related to environmental quality.

— During his six-month stay at RFF, Karl-Göran Mäler worked on a manuscript in which he seeks to integrate his studies of various environmental issues into economic theory. Mäler has developed proofs for a number of propositions flowing from the general equilibrium approach to environmental problems propounded in *Economics and the Environment: A Materials Balance Approach*, by Allen V. Kneese, Robert U. Ayres, and Ralph C. d'Arge, published by RFF in December 1970. He also has analyzed the dynamic properties of the equilibrium approach within a system experiencing economic change. Other theoretical work is being continued by Ralph d'Arge at the University of California in Riverside under a previous RFF grant to the University. This work is focused on a number of macroeconomic issues, including the effects of environmental constraints on economic growth and on the optimum rate at which society's nonrenewable resources may be used.

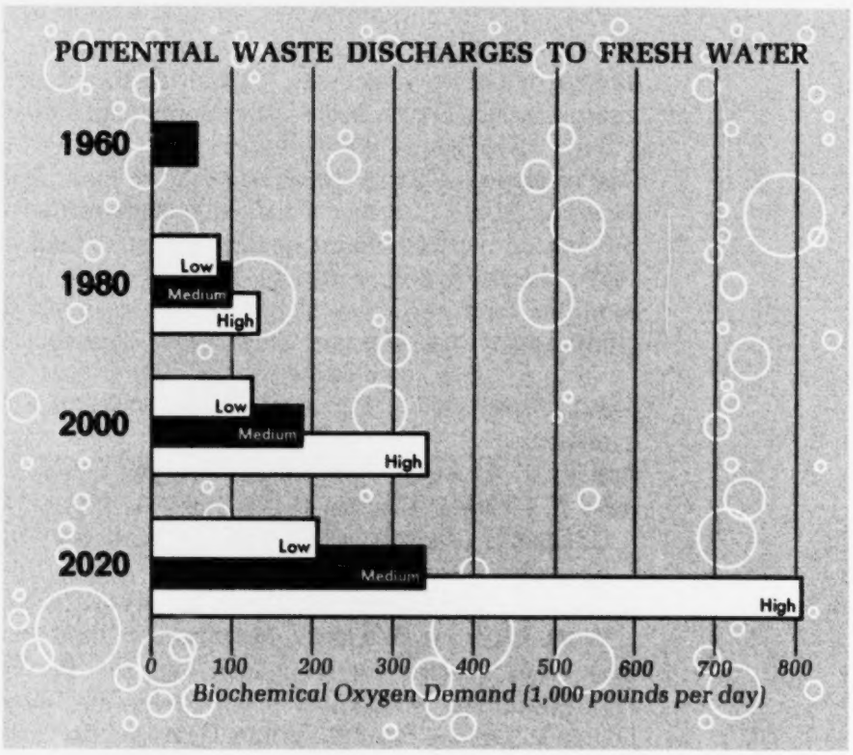
D'Arge is working on another project, supported by a grant of $7,000 made during the year to the University of California, in which he is attempting to assess the effects of cost increases induced by environmental controls on the international trade position of various countries. At the outset d'Arge devised an econometric model to gauge effects of cost increases on balance of trade and related international income effects. Empirical applications to several countries have already been made. The first report on this work, "International Trade, Domestic Income, and Environmental Controls" was published during the year in *Managing the Environment: International Economic Cooperation for Pollution Control*, edited by Allen Kneese, Sidney Rolfe, and Joseph Harned (Praeger, 1971).

— The question of how, if at all, the aggregated measures of economic change, such as the gross national product, should be altered to reflect environmental degradation and the costs incurred in its control is of concern to economists and government statisticians. A related question is whether these general measures should be supplemented or possibly replaced with a new set of environmental indicators. Over the past year RFF has engaged in considerable work in this area. Orris Herfindahl and Allen Kneese have analyzed the range of issues in a prepared presentation at a National Bureau of Economic Research conference in November 1971. Further work on this subject is being carried out by Mancur Olson, under a grant of $21,700 to the University of Maryland. Olson, who was an RFF visiting scholar during the summer, is also preparing a paper for the November NBER conference. In order to test certain theoretical propositions, RFF is sponsoring experimental empirical work on the national accounts of Norway. Henry Peskin of the Institute for Defense Analyses is conducting this study on a consultancy basis in collaboration with Odd Aukrust of the Central Statistical Office of Norway.

To explore the possible magnitude of future environmental problems and the ways in which they may be affected by alternative management strategies as well as by population growth and changes in population characteristics, research into environmental quality included participation in the construction of a resource-residuals projection model. It is a part of the demographic-environmental model described on page 79. In addition, through a research agreement made during the year, the International Research and Technology Corporation is assisting in this effort.

— Another area of research concerns the functioning of political processes and the possibility of improving them so that they better reflect the preferences of society on issues of environmental quality. During the year, basic work on public choice problems was pursued at RFF by Haefele and at Harvard University by John Jackson, assistant professor of government, under an RFF grant. Jackson is studying the relationship between the supply of municipal services and the electoral strategies of candidates; Haefele's concern is with preference aggregation under various assumptions about political boundaries. Currently he is working out a set of political variables for the models that are being constructed in the regional residuals management project. A report on some results of his research was published in the June issue of the *American Economic Review* under the title, "A Utility Theory of Representative Government."

— As a result of environmental research supported by an RFF grant to the University of New Mexico, *The Outlook for Water: Quality, Quantity, and National Growth*, by Nathaniel Wollman



The chart above, based on Table 40 in The Outlook for Water *by Nathaniel Wollman and Gilbert W. Bonem, brings out two important aspects of RFF's new study of projected water quality and quantity in the United States. First is the strong influence of growth in economic activity and population upon prospects for the future. Alternative assumptions of low, medium, or high growth rates for both factors result in enormous differences in the projections for a given year. Second, is the steady increase in the generation of wastes that pollute water, regardless of which assumption is used. The estimates shown in the chart relate to the BOD load before treatment.*

and Gilbert W. Bonem, was published during the year. It provides projections of regional demand and supply of U.S. water resources through the year 2020. The authors develop three alternative programs for meeting indicated regional shortages: minimum treatment, minimum storage, and minimum cost. They emphasize that "shortage" is a matter of both quality and quantity and that ultimately the method of coping with it will reflect social preferences. Will the public be willing to pay the price for the standard of water quality it demands? According to their projections, new technologies must be found if water of high quality is to be widely available fifty years hence. Even earlier, rapid growth and a demand for increased water quality will drive operating costs upward, especially the cost of waste treatment.

The authors pinpoint some of the vital areas requiring additional research before sound water management policies can be developed. More important, they provide a basis for further advances in the art of projecting supply and demand.

Two other books were sent to press during the program year. *Environmental Quality Analysis: Theory and Method in the Social Sciences* brings together fourteen papers presented at RFF's conference on environmental quality research held in the summer of 1970. The collection, edited by Kneese and Bower, is an extensive sampling from the work of the RFF program on the quality of the environment over the past few years. Contributors are:

Ralph C. d'Arge — "Economic Growth and the Natural Environment"
Robert U. Ayres — "A Materials-Process-Product Model"
John V. Krutilla, Charles J. Cicchetti, A. Myrick Freeman III, and Clifford S. Russell — "Observations on the Economics of Irreplaceable Assets"
Clifford S. Russell and Walter O. Spofford, Jr. — "A Quantitative Framework for Residuals Management Decisions"
Max R. Langham, Joseph C. Headley, and W. Frank Edwards — "Agricultural Pesticides: Productivity and Externalities"
Lester B. Lave — "Air Pollution Damage: Some Difficulty in Estimating the Value of Abatement"
A. Myrick Freeman III — "The Distribution of Environmental Quality"
Edwin T. Haefele — "Environmental Quality as a Problem of Social Choice"
Joseph L. Sax — "Legal Strategies Applicable to Environmental Quality Management Decisions"
Delbert C. Miller — "Power Structure Studies and Environmental Quality Management: The Study of Powerful Urban Problem Oriented Leaders in Northeastern Megalopolis"

The book is scheduled for publication early in 1972.

The second book, *Alternatives to the Internal Combustion Engine*, by Robert U. Ayres and Richard P. McKenna, explores ways in which the internal combustion engine might be modified and also investigates such alternatives as steam and electrical propulsion systems. Publication is expected by mid-1972.

Natural Environments

Natural environments have many potential uses. They are nature's laboratory for experiments in biological evolution and ecological succession; they preserve genetic stocks that would be lost through the interference of modern man and that are sources of other materials for scientific research; and they provide sites for a specialized kind of recreation for people who feel the need of contact with unspoiled nature. But natural environments can serve other, and incompatible, purposes. These remote areas often are used for mining, logging, grazing, or irrigation farming; often they are the sites of power dams. These are the most common ways by which wilderness and wildlands have been transformed to help meet the material requirements of an industrial economy. Such changes have greatly reduced the stock of wild rivers and lands in the United States. The Wilderness Act of 1964 and the Wild and Scenic Rivers legislation of 1968 reflect a deep and growing public concern that not all of the wild and scenic areas in nature be irretrievably altered in pursuit of material consumption objectives.

Much of the research in RFF's natural environments program is directed toward the issues that arise in choosing among the various alternative uses of natural areas; one alternative, of course, is preservation of such areas for uses compatible with their continued existence in their natural state. The program consequently includes not only problems of allocation but also those of administering wildlands, wildlife, and scenic resources. During the past year, the first round of research in many of the component parts of the program was ready either in published form or for critical discussion.

Drafts of some of this work were reviewed in August at a natural environments workshop at Missoula, Montana, held by RFF in cooperation with the School of Forestry of the University of Montana and the Forest Sciences Laboratory Wilderness Research Project of the U.S. Forest Service. At the close of the year the papers were being revised by their authors to reflect the out-

come of the workshop discussion. Their publication in a single volume is planned.

THE MONTANA WORKSHOP PAPERS

The Incidence of Technological Change

In a theoretical inquiry, V. Kerry Smith has investigated the conditions under which technological change would affect either the explicit or shadow price behavior of the services provided by natural environments relative to other goods and services. Smith, assistant professor in the Department of Quantitative Analysis and Control at Bowling Green State University, came to RFF as a visiting scholar during the program year. In his paper, "The Incidence of Technological Change Among Different Uses of Environmental Resources," he examines different community preferences within the context of a given production scheme, and identifies several critical parameters.

Smith finds that technological innovation affecting producible goods increases the relative prices of environmental services. He indicates the close relationship between the rate of relative price appreciation, the availability of substitutes for the services of natural environments, the respective marginal contributions of all commodities to total welfare, and the importance of each individual commodity or service to the community's overall standard of living. The analysis, made in a general equilibrium framework, provides support for the Cicchetti-Krutilla partial equilibrium approximation mentioned on page 47. The results point out the conditions under which the rate of price appreciation would be the same under both partial and general equilibrium models. Accordingly, the study has general implications for the relationship between partial and general equilibrium analysis for analyzing price behavior in the presence of technological change. Also, the relationships between alternative preference functions and concomitant community demand patterns are relevant to individual consumer demand theory.

During the year Smith examined the determinants of technological innovation as another procedure for analyzing nonuniform technical change. He studied the effect of nonpriced common property resources on the path of technical change chosen by the firm. The results of his model indicate that technological innovation will make extensive use of our common property resources over time. Furthermore, he concludes that an alteration in the pricing policy, such as an imposition of an effluent charge, does not necessarily increase the discounted cost stream for all industries. At year's end he had completed a paper, "The Implications of Common Property Resources for Technical Change," for possible publication.

Smith's work is supported by RFF grants to his university. A second grant of $7,800 was made during the program year.

Wilderness Areas for Quality Recreational Experiences

Not all extractive industrial activities on wildlands are necessarily incompatible with all forms of recreational activities. Similarly, not all forms of recreational activity are compatible with each other in a given outdoor environment. How many wilderness users ought to be admitted at any time to a given wilderness area, and what forms of activity are compatible with the objectives of the Wilderness Act to provide for environments "untrammelled by man"?

In his paper, "Strategies and Problems in Managing for Wilderness Quality," George Stankey of the Wilderness Research Project, U.S. Forest Service, sorts out many of the issues about which there has been much confusion, thus providing better perspectives on the objectives and problems associated with the use of wilderness areas. A wilderness recreation experience differs from other types of recreation in *kind,* rather than quality. It is therefore inappropriate, he concludes, to consider one form of recreation as representing a higher- or lower-quality recreation experience than another.

The problem then is to ascertain the total range of tastes with respect to outdoor recreation in order that wilderness (and other wildlands) can be managed so as to indulge the whole range of preferences in their appropriate settings. In his study, Stankey identifies the wilderness users who share the values reflected in the Wilderness Act, and explores their attitudes toward various circumstances and conditions of wilderness uses.

In a complementary research paper, "Some Economic Issues Involved in Planning Wilderness Recreation," Cicchetti makes use of various simultaneous multiple regression models to analyze the data gathered by Stankey on four wilderness areas. The purpose of this study is to test various hypotheses, which a priori judgment indicates might explain differences in preferences and tastes among wilderness users. Cicchetti also seeks to determine whether the scale of wilderness purism developed by Stankey can be used to predict visitor reaction to various wilderness experiences.

Optimal Recreation Density for Wilderness Areas

Specifying a management policy for administering a wilderness area for maximum social benefit is important in every instance. It may be even more important when the issue is whether a natural area that qualifies for inclusion within the National Wilderness System under the 1964 Act should be included or be devoted to purposes incompatible with its remaining a wilderness area.

One way to approach a judgment on adding an area of this kind to the wilderness system is to estimate whether its social benefit would be greater in one use or in another. To do so, it is important to know how the total benefit from a wilderness area is affected by the number of users. At what point does the addition of one more wilderness user so reduce the enjoyment of all others that there is a decline in the aggregate social benefit from the area? If this point of maximum value is determined, it can be compared with the corresponding value of the alternative uses precluded by preserving the area in its natural state.

The optimal recreational capacity and its determination was the subject of a paper by Anthony Fisher and John Krutilla, "Operational Concepts of Optimal Recreation Capacity for Low-Density Recreation Facilities."

The Wilderness Research Project of the Forest Service and the Natural Environments Program at Resources for the Future are continuing to cooperate in this work.

Demand for Recreational Uses of Forest Lands

Outdoor recreation has many forms. Not all take place at a national park where some unique natural feature is the primary objective of the visit. Nor do all devotees of the out-of-doors require, or even prefer, the fairly austere conditions that the Wilderness Act imposes for de jure wilderness areas. On the basis of research performed at Oregon State University, Professors Jack Edwards, Kenneth Gibbs, Leo Guedry, and Herbert Stoevener address some methodological issues associated with the derivation of demand functions for the more ordinary recreational uses of forest lands. In their paper, "The Demand for Non-unique Resource-based Recreation," they present the by now conventional Clawson-Knetsch model, indicating its particular characteristics, conditions under which it would yield the estimates sought, and the potential difficulties under conditions when the formulation is not necessarily appropriate. An alternative formulation is provided for conditions that differ from those underlying the Clawson-Knetsch model, and the results of an empirical application of the alternative model are reported.

Economic Evaluation of a Fugitive Recreational Resource

The rolling, pothole-pocked agricultural lands of central and southern Alberta, Saskatchewan, and Manitoba, together with neighboring parts of Minnesota and the Dakotas provide the primary nesting habitat for North American migratory ducks. Representing only about 10 percent of the continental breeding grounds, these lands produce over half the continental supply of migratory ducks. The ducks, migrating along the Pacific, Central, and Mississippi flyways, provide the source of much of the U.S. recrea-

tional waterfowl hunting, viewing, and photographing. The prairie pothole country is thus a principal producer of migratory waterfowl as well as grain.

Although much research attention has been devoted to the efficient allocation of land for agricultural purposes, little has been given to the optimal allocation of the wetlands for recreational services. Gardner Brown and Judd Hammack address this problem in their paper, "Economic Evaluation of a Fugitive Recreational Resource: Migratory Waterfowl." They begin with a theoretical model that yields an estimate of the marginal value of waterfowl to hunters. They then formulate a model for determining optimal levels of waterfowl breeding populations and nesting ponds, subject to the dynamic constraint of waterfowl population growth as affected by human predation. Optimal levels in this model are those that maximize the present value of the difference between recreation hunting benefits (the hunters' consumer surplus), as developed from the imputed demand schedules, and the cost (in terms of forgone agricultural opportunities) of the breeding ponds. A preliminary application of this analysis to the question of wetlands allocation suggests that the observed number of breeders and ponds has been less than optimal in recent years.

Another RFF study involving the conflict between use of wetlands for resting and nesting habitat for migratory waterfowl, on the one hand, and drainage for purposes of increasing agricultural production on the other, was published during the year: *Competition for Wetlands in the Midwest*, by Jon Goldstein. A description of the study and the principal conclusions were given in last year's annual report.

Classification of Aquatic Environments

The multitude of water bodies in the United States ranging in size from the Great Lakes to minor ponds are subject to an almost endless variety of demands, all the way from use of their waste-assimilative capacity to use for recreational and research purposes. Some of these uses are compatible, others are conflicting, and yet others have irreversible adverse effects on the character of the aquatic environment in question. Andrew Sheldon in his paper, "A Quantitative Approach to the Classification of Inland Waters," concludes that prudent management of these lakes, streams, springs, and swamps, calls for a great deal of information that should be presented in a form digestible by those responsible for making decisions governing the fate of water bodies.

As a step toward developing such information, Sheldon, an aquatic ecologist at the University of Montana, has investigated the classification of aquatic environments in a continuation of work begun as a visiting scholar at RFF. His emphasis is basically on procedures, because data in the field of comparative limnology

are most meager. Sheldon views his study as a first-generation effort, undertaken to provide a point of departure for the time when availability of test data will permit refinement of classification techniques and their interpretation, in turn leading to classifications relevant to various resource management objectives.

Visual Qualities of the Landscape

Not all qualities of the environment are as yet subject to analysis in terms of benefit-cost comparisons. Visual attributes of landscape are an example. They must be much better understood before their significance for environmental quality can be measured. In his paper, "Aesthetic Dimensions of the Landscape," Burton Litton of the School of Design, University of California, Berkeley, presents means of viewing, identifying, and describing aesthetic attributes of the backcountry environment. He proposes ways in which such awareness can be expressed in more objective terms than formerly as a guide to decisions by resource managers in land management agencies whose actions result in landscape modifications.

In a companion paper, "Appraising the Objectivity of Landscape Dimensions," Kenneth Craik of the Department of Psychology, University of California, Berkeley, evaluates the objective validity of the dimensions developed in Litton's work. Results of Craik's analysis suggest the approach developed by Litton may be widely applicable in situations encountered by resource managers who are not professional designers.

ALLOCATION OF ENVIRONMENTAL RESOURCES

The Economics of Environmental Preservation

Charles Cicchetti, Anthony Fisher, and John Krutilla collaborated in a basic theoretical and empirical study of the economics of environmental preservation. Some attributes of the natural environment — for example, the grand scenic wonders or the genetic information of a given species — are results of evolution, geomorphology, or ecological succession measurable only in time spans that far exceed the planning horizons of mankind. Man-made decisions that may irreversibly affect the environment entail a vastly greater responsibility than do decisions whose consequences can be undone if hindsight shows them to be undesirable. Yet the decision criteria (e.g., conventional benefit-cost analysis) under which such choices are usually made typically involve myopic bias. Employing the analytics of optimal control theory, the new study develops basic decision criteria for problems involving choice between incompatible alternatives with irreversible conse-

quences and then applies them to a particular case to test their operational and practical value. A paper by the three authors, "The Economics of Environmental Preservation," has been accepted for publication in the *American Economic Review.*

Optimal Use of Natural Environments

Another aspect of Fisher's continuing work on the theory of optimal allocation of environmental resources concerns the choice between preservation and development of a natural environment under conditions of uncertainty. Uncertainty surrounds even our best estimates of the streams of costs and benefits of alternative uses of environmental resources. Fisher concludes that uncertainty about cost and benefits reduces the expected present value of benefits from an irreversible development. This suggests, in turn, that even assuming perfect neutrality with respect to risk, less of a given natural area should be developed than would be optimal if all the costs and benefits were known with certainty. That conclusion is strengthened if there is an aversion to risk, coupled with uncertainty regarding the cost and benefit streams. The results of this work were reported in a paper entitled "Uncertainty, Information, and the Evaluation of Investments with Environmental Effects" given before the North American Summer Meetings of the Econometric Society in Boulder, Colorado.

During the year a grant of slightly more than $29,000 was made to Brown University, where Fisher is assistant professor of economics, to support his work from January 1971 through August 1972. During most of that period he will be at RFF headquarters as a visiting scholar.

Evaluation of Benefits from Environmental Resources

Shortsighted decisions about resource allocations are frequently caused by failure to gauge probable future changes in the relative value of alternative outputs from a given set of resources. If demand for the services of an asset increases, the value of the asset itself may change, the nature and extent of the change being determined by the availability and price of services of like quality from other sources. While the supply of unspoiled natural environments cannot be increased but may diminish, and while their value in their pristine state can be expected to increase, their value as suppliers of industrial materials or other alternative products will depend on the progress of technology in the production of the goods or services in question. A simple model playing out the implications of these assumed conditions has been developed in a study by Charles Cicchetti and John Krutilla. Their paper, "Evaluating Benefits of Environmental Resources with Special Application to Scenic Resources," is scheduled for publication in the *Natural Resources Journal.*

Study of Dynamics and Interaction of Wildlife Populations

Resources management generally implies an effort to find the optimal mix of outputs that can be provided by the combination of resources under a manager's control. This should be no less true of wildlife management than of resources more generally. A grant of $14,000 was made to Colorado State University to support a study of the ecology of wildlife populations. The work, under the direction of Jack E. Gross, assistant professor of wildlife management, is expected to cover a two-year period. The research seeks to clarify the range of outputs that can be produced from a given wildlife resource, to identify the ecological mechanisms that can be manipulated by wildlife managers to produce the desired outputs, to develop management strategies that will be more likely to produce the optimal mix of outputs, and to design procedures for evaluating the application of such strategies.

A model that simulates the demographic behavior of a single species under various management practices and habitat modifications has been built and validated. Work is now under way on a simulator that will mimic the demographic behavior of several wildlife species in competition on the same range with other wildlife or with domestic stock. Data for this purpose are being collected from the National Bison Range where seven species (mule deer, whitetail deer, elk, bighorn sheep, pronghorn, Rocky Mountain goat, and bison) are found.

The Trans-Alaska Pipeline

While the proposed Trans-Alaska pipeline involves a development project of major economic importance, there has also been much concern over the environmental risks posed by the project. Charles Cicchetti, utilizing data provided by various industrial, governmental, and academic sources, is seeking to illuminate the various economic and environmental issues and to lend perspective to the problem within a decision framework. He has developed a computer model that makes it possible to consider the effects of various alternatives and thus to evaluate the implications of various assumptions and assertions that have been voiced during the pipeline controversy.

Land and Water

Work concerned with land and water problems continues in a number of universities with RFF support. At Utah State University, research is focusing on the changes that are taking place in most rural (or, more precisely, nonmetropolitan) areas; and at Kansas State University, U.S. agricultural policy in relation to world trade is being studied. At Southern Methodist University, the legal implications of weather modification are being examined; and at the Università degli Studi, in Italy, a three-year project to develop computational and survey procedures for evaluating flood-control policies was completed. In addition, a case study of land and water management in the state of Florida is in preparation under RFF sponsorship.

Plans are being made to shape the joint land and water program to reflect the current shift in emphasis toward the study of water problems as they relate to natural resource planning in general and to land use planning in particular. During the past year eight books resulting from research done by staff or grantee scholars were published or brought close to publication. All have been referred to in previous annual reports as research progressed, but they are mentioned briefly below as an indication of the effort that has gone into these two interrelated fields of resource use and management over the past few years.

SUBURBAN LAND CONVERSION

Suburban Land Conversion in the United States: An Economic and Governmental Process, by Marion Clawson, which was published in September, results from several years of research on the processes by which urban development spreads from the suburban fringe outward into the countryside.

If there is no change in the operation of the suburban land conversion process, suburbs will continue to spread outward, with

a great deal of idle or vacant land intermingled among the developed subdivisions; costs of public services will be high because of the spotty growth pattern; the price of undeveloped land may increase at a lower rate but will probably remain high; and housing will still be too costly for people in the lower half of the income range. From his study of the way in which this pattern has developed and the possibilities of change, Clawson believes that there are ways in which public and private measures of land planning and zoning can be reinforced to overcome some of the obstructions in the working out of the suburban land market.

A somewhat similar study of urbanization in Great Britain will be published toward the end of 1972 by Allen and Unwin. Under an RFF grant to the Political and Economic Planning organization (PEP), research in England, under way for several years, has paralleled as far as possible the techniques and general approaches used by RFF in the preparation of the U.S. land conversion book. Emphasis in England has been on the London-Liverpool axis, an area that bears distinct similarities to the northeastern urban complex in the United States. The study, *Megalopolis Denied: Planning and the Containment of Urban England, 1945–1970,* by Peter Hall, with Ray Thomas, Roy Drewett, and Harry Gracey, will be in two volumes: (I) *Urban and Metropolitan Growth Processes,* and (II) *The Planning System: Objectives, Operations, and Impacts.*

The joint projects are now entering a third phase. Clawson and Hall are preparing a manuscript in which they compare the characteristics of urban growth in the United States and Great Britain and examine the contributions of government to changing land use in both countries.

OTHER STUDIES OF U.S. LAND USE

Professional Forestry

As a science and a profession, forestry has been practiced in the United States for barely seventy years. In *Professional Forestry in the United States,* Henry Clepper, formerly executive secretary of the Society of American Foresters, describes the development of forestry. He traces the contributions of foresters to federal, state, and industrial forestry programs since the first forestry schools were established — shortly after the forest conservation movement succeeded in obtaining legislation to establish forest reserves — to the present. Their contributions have made possible the transition from an era of forest exploitation to one of intensive scientific management.

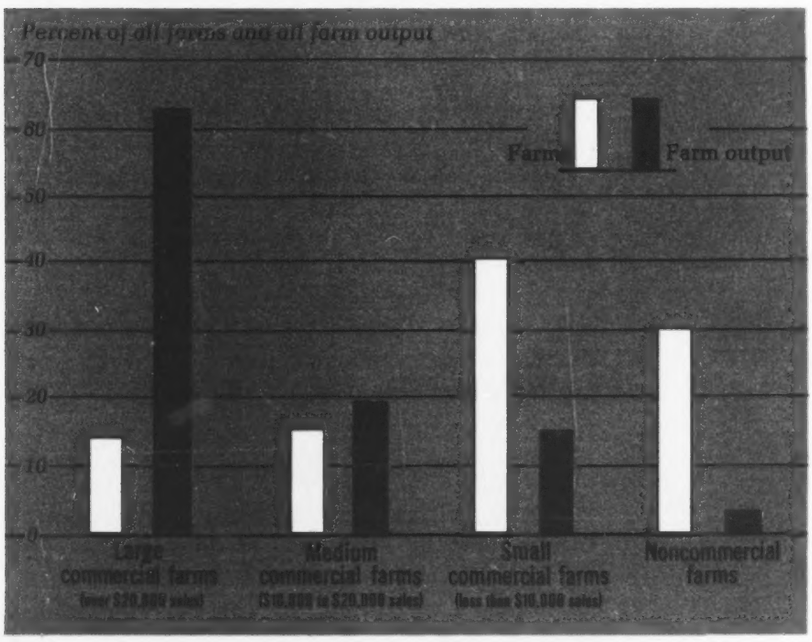
The book was in press at the end of the program year, scheduled for publication in December. The author's research was supported by an RFF grant to the Forest History Society.

The Nation's Land

In a book designed for college students and general readers, *America's Land and Its Uses,* Marion Clawson has drawn upon many years of his own research and that of RFF colleagues to present a compact nontechnical account of the nation's land — its history, present trends, and future possibilities. The three great traditional uses — farming, grazing, and forestry — are dealt with in turn, followed by sections on the two uses that present the largest number of new problems — urbanization and outdoor recreation. In press at the end of the program year, the book is scheduled for publication early in 1972.

Agricultural Policies and Programs

A study of U.S. agricultural policies and programs since World War I has been in progress for several years at Michigan State University. By the end of this program year a manuscript resulting from the project was being edited for late 1972 publication under the title "Overproduction Trap in U.S. Agriculture."



In 1965, total farm output was divided unevenly among the various categories of farms. About one-seventh of the largest farms produced well over half the total output. Nearly a million and a half small commercial farms had gross sales of less than $10,000; as net incomes were only about one-half that figure, many operators were at about the poverty line.

The prime focus of the study is on resource allocation -- how much labor, capital, and land have been directed to the production of agricultural commodities, on what basis the resource allocations were made, and by whom, and what the effect has been on agricultural incomes, on payments to factors of production, and on agricultural output. Described in quantitative terms are some persistent tendencies to overinvestment of capital (accompanied at times by some underinvestment), a persistent tendency to overallocation of manpower to agriculture, and a consequent persistent tendency to a level of output not planned for when the resource allocation was initially made.

The results of these allocative arrangements are analyzed in relation to resource use and efficiency. The study also provides information and some new analytical concepts of interest to welfare economists, sociologists, and agricultural policy makers.

Glenn L. Johnson, professor of agricultural economics at Michigan State, who directed the grant-supported project, and Leroy Quance, agricultural economist with the Natural Resources Economics Division of USDA's Economic Research Service, wrote much of the study and edited the whole. Six other scholars contributed detailed analyses of particular problems.

Wildlife Management

During the program year RFF made a grant of $17,700 to the University of Montana in partial support of work being conducted on biological, economic, and policy aspects of wildlife management. Preliminary work on the study was carried out under an earlier grant by Arnold Bolle, dean of the School of Forestry at the University, and Richard D. Taber, professor of wildlife in the College of Forest Resources, University of Washington. They will now compare data on current policies and administrative procedures relating to the management of North American wildlife with similar data from other countries.

Land Use and Water Management in Florida

A study of land use and water management policy with respect to environmentally critical areas in Florida has been undertaken by Luther Carter, who is on leave from *Science*, the journal of the American Association for the Advancement of Science, while working at RFF headquarters. Carter will explore the distinctive ecological and hydrological characteristics of the state and some of the ways they have been affected by human incursions. His approach is to present the policy questions by means of selected case histories of specific problems, such as the Dade County jetport and the Big Cypress watershed, the Cross-Florida Barge Canal and the Oklawaha River Basin, and real estate development affecting coastal wetlands.

FOREIGN AGRICULTURE

The Mekong Basin

The staff report, *Agricultural Development in the Mekong Basin: Goals, Priorities, and Strategies,* submitted to the World Bank at the end of the last program year, was published by RFF for general distribution in May of 1971. Investigations on how best to harness the flow of the Mekong River for productive, peaceful purposes have continued under UN auspices despite conflict in three of the four countries that share the watershed — Laos, Cambodia, and South Vietnam; the fourth is Thailand.

The authors of the report assess the demand/supply conditions for expanded agriculture in the Lower Basin, specify the measures that are needed to achieve favorable conditions for modernizing agriculture, and inquire into the criteria — sociological as well as physical and economic — that might best serve to establish a sequence of development.

Agriculture in the Middle East

Another RFF study of agricultural potential in less-developed areas of the world was published early in 1971 by the American Elsevier Publishing Company. The countries considered are Egypt, Iraq, Israel, Jordan, Lebanon, and Syria. The authors believe these countries are physically capable of realizing large increases in agricultural output over the next two or three decades, but that these increases are dependent on a number of factors that include the use of modern farm technology and management. The findings of the study are backed up for each country with historical data on crop acreages, yields, and production; livestock numbers and production; farm inputs of various kinds; farm output; and soil conditions.

The book, *The Agricultural Potential of the Middle East,* by Marion Clawson, Hans Landsberg, and Lyle Alexander, is one of a series of five volumes, "The Middle East: Economic and Political Problems and Prospects," resulting from a joint Rand Corporation–Resources for the Future research program supported by a special grant from the Ford Foundation.

STUDIES OF WATER USE

Economic Performance of Public Investments

Benefit-cost analyses have long been used as planning guides for decisions about public investments, particularly in the water resources field, but little is known about the accuracy of the estimates because few agencies have developed procedures for monitoring the economic performance of projects once they have

Source	Estimates of quantities available per year (million acre-feet)	Indicated range of costs per acre-foot (dollars)
Reduction of conveyance losses:		
Colorado Basin	1.5	2—42
Great Basin	0.6	2—42
Pacific Northwest	3.4	2—42
South Pacific	2.0	2—42
Missouri	1.6	2—42
Evaporation retardation from small ponds and reservoirs	0.5	12—24
Transfers from agriculture:		
Arizona	1.2—1.6	28
Colorado	not known	15—32
Texas High Plains	4.0	81—119
California	0.8	18—106
Additional surface development:		
Western Gulf	11.0	3—19
Central Pacific	21.0	3—41
Weather modification (Upper Colorado Basin)	1.9	1—2
Wastewater reclamation: Southern California	0.7	13—32
Desalination	unlimited	100+
Vegetative management and snow fencing	9.0	2—23
Phreatophyte and riparian vegetative control	not known but potentially large	1—57
Minimum total availability	59.2	

Perhaps the most obvious way of increasing the usable supply of fresh water in one river basin is to bring in water from another basin, but there are several alternative methods which in a given situation might cost less. The estimates above are from the recent RFF study, Interbasin Transfers of Water. *Although some of the cost figures are subject to detailed qualifications and explanations not shown here, they are careful approximations that can be compared usefully with the authors' blanket estimate of $30 to $108 per acre-foot for some of the interbasin transfer projects that are now under construction or are being seriously considered.*

been undertaken. In *The Economic Performance of Public Investment: An Ex Post Evaluation of Water Resource Investments,* which was in press at the end of the program year, Robert H. Haveman, professor of economics at the University of Wisconsin at Madison, analyzes the procedures for estimating primary benefits and costs by developing a method for appraising the economic performance of public investments and applying it in a series of case studies of public investments in the water resources area. Finding serious discrepancies between projected and realized costs and benefits, he suggests that a constant and more substantial monitoring and evaluation of completed projects could lead to important improvements in benefit-cost estimating procedures and to correcting persistent biases in these procedures. Such assessments might also throw light on the vaguely understood relationships between public investments and changes in income distribution, regional growth, and environmental quality.

Large-Scale Water Transfers

Physical transfers of water between river basins have long been put forward as solutions to problems of water quantity and quality, but many questions need to be answered if such transfers are to receive the unbiased and informed evaluation required for sound policy formulation. Some of these questions are explored in *Interbasin Transfers of Water: Economic Issues and Impacts,* published in 1971. The authors are Charles W. Howe, formerly head of the RFF water resources program and now professor of economics at the University of Colorado, and K. William Easter, formerly with the U.S. Bureau of the Budget and now consultant on resource economics with the Ford Foundation. What is the economic demand for water in the West, the locale of most of the large-scale transfer proposals? Are interbasin transfers the least-cost means of providing additional water? What short-term and long-term impacts are the transfers likely to have on the importing region and on other regions? Concentrating on agriculture, which is the principal user of water in the West, the authors survey current knowledge about the direct and indirect benefits attributable to water and the potential costs of interbasin transfers. They also examine alternatives to transfers by such means as reduced conveyance losses, additional surface development, wastewater reclamation, desalination, vegetative management and phreatophyte control, evaporation retardation, and transfer of water from agriculture to other uses.

Drought and Urban Water Supply Planning

Desire to guard against the hazards of drought has been a determining factor in the planning and construction of municipal

water systems throughout most of the United States, particularly in areas where there is a wide range in precipitation. In *Drought and Water Supply*, published during the program year, Clifford Russell of the RFF staff, David Arey of Southern Illinois University, Carbondale, and Robert Kates of Clark University, report on experience in Massachusetts during the drought of the early sixties and its implications for municipal planning. The authors use a demand-supply ratio to measure the relative inadequacy of a given water system, and develop a model that allows for an optimal balancing of the cost of additional storage against expected losses from future droughts. The authors' findings, though based on experience in Massachusetts, are applicable to problems of water resource planning and natural resource management in other areas.

Future Demand for Water

A study undertaken by RFF for the National Water Commission was completed during the year, and a final report, by Charles Howe, Clifford Russell, Robert Young, and William Vaughan, was submitted to the Commission in March. The report consisted of a summary text followed by three technical studies dealing with urban, industrial, and agricultural demands for water. The summary has since been released by the Commission for public distribution through the National Technical Information Service under the title *Summary of Future Water Demands: The impacts of technological change, public policies, and changing market conditions on the water use patterns of selected sectors of the United States economy, 1970-1990.* [See page 106.]

Energy and Minerals

Much of the work of RFF's energy and minerals program during the year centered upon energy policy making in the United States — an area that is one of the program's two main lines of research. Within the policy field, research and development on energy technologies and on environmental problems associated with energy use have assumed increasing importance. Results of a study on energy policy research needs and of a forum on energy and the environment held this year are reported below. One of the books published during the year reports on several years of research on domestic petroleum conservation regulations and practices. Another book, on natural gas regulation, is being edited for publication next year.

A second main line of research deals with international aspects of energy and minerals. The results of several years of staff and grant-supported work on Middle Eastern oil, world iron ore, foreign investments in the minerals industries, and the world energy economy were published or in press during the year. Another book — on the world petroleum market — is being prepared for publication.

Milton F. Searl, recently with the Energy Policy Staff of the President's Office of Science and Technology, joined the staff in July. In June, Zuhayr Mikdashi, of the American University of Beirut, began a stay of approximately a year as a visiting scholar. Jan Zwartendyk, now with the Canadian Department of Energy, Mines and Resources, was a temporary staff member for several months during the spring and summer.

BACKGROUND FOR DOMESTIC POLICY

A growing awareness of the environmental problems associated with energy production and use has also contributed to renewed public concern that the nation is in danger of "running out" of mineral fuel reserves. As a consequence, strong interest has de-

veloped in the prospects for technological research and development as a means of circumventing or reducing problems of short supply. R&D has, in fact, become a focal point in the area of energy policy, joining such long-standing policy issues as federal and state regulation of the oil, natural gas, and electricity industries; tax and other incentives to private industries engaged in the exploration and development of mineral fuel reserves; oil imports; and the disposition and management of federal lands that are rich in mineral fuel resources.

Energy Research Needs

Recognizing the growing role of energy R&D as an element in overall energy policy, the National Science Foundation requested RFF to undertake a study specifying research needs in the energy policy area, broadly defined. At the end of the program year a draft report had been completed for formal submission to the NSF in October of 1971.

The report identifies a large number of matters on which further research is essential to gain an improved understanding of the long-term outlook in the United States, and to devise policies to deal with the situation. Broadly, the subjects covered are: the forces that influence energy consumption, the future of domestic mineral fuel reserves, research and development possibilities in energy production and use, the environmental impacts of energy production and utilization activities, and the public policies that significantly affect energy industry operations.

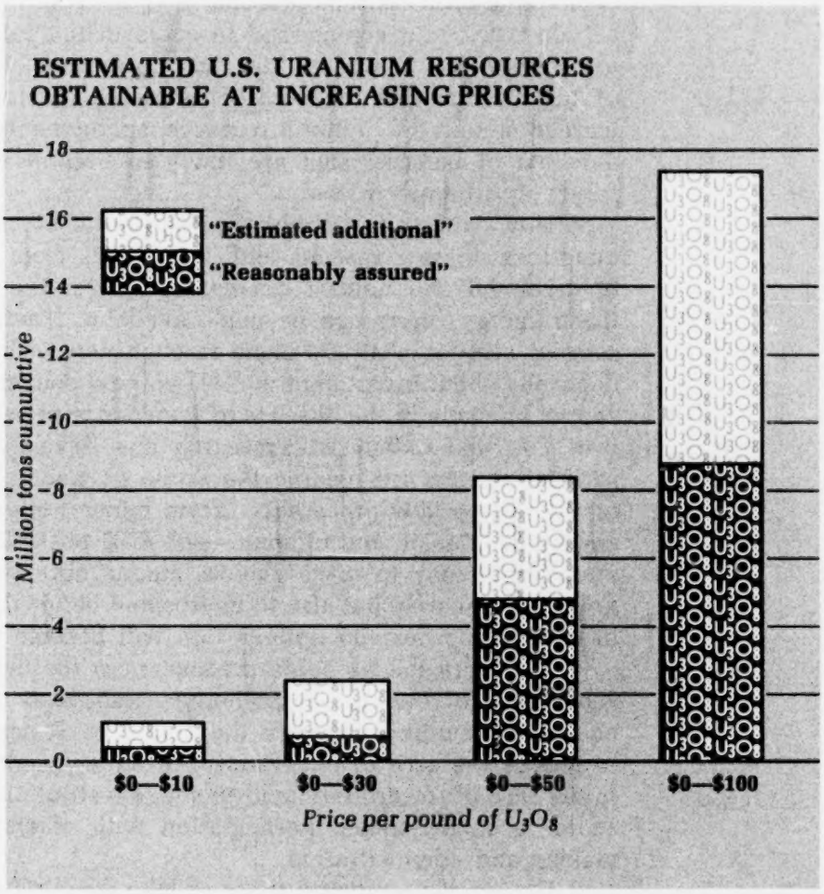
The detailed suggestions offered in the report are based on exploration of the following major questions:

1) How much flexibility does the United States economy possess with respect to future growth in total energy consumption? What are the possible rates and patterns of energy growth that are compatible with alternative rates and patterns of overall economic growth?

2) How much flexibility can there be with respect to the composition of total energy consumption in terms of energy forms (i.e., gaseous, liquid, and electric energy)? There is a substantial degree of substitutability among forms today. How far can substitutability be carried and at what cost?

3) How much flexibility can there be with respect to the particular mineral fuels from which the energy forms are derived? At present all mineral fuels can be converted to electricity. To what extent, and at what costs, will improved technology permit conversion of, say, coal and shale to liquid and gaseous forms?

4) To what extent, and at what cost, are the nation's mineral fuel reserves expandable? The resource base for all mineral fuels is many times greater than the currently known, commercially



A pound of pure nuclear fuel — say uranium-235 — is, in energy terms, the equivalent of about 3 million pounds of coal. Therefore the cost of extracting uranium ores from the ground and converting them to the uranium concentrate U_3O_8 could increase greatly without having a marked effect on the cost of generating useful energy from the uranium contained. The closer technology comes to converting all of natural uranium into nuclear fuel (which depends on successful development of advanced converters and, eventually, breeder reactors), the smaller will be the effect on the cost of the electricity produced. Even with the type of light-water reactors now being built, which "burn" essentially only the naturally fissionable uranium-235 and an approximately equal amount of plutonium produced from uranium-238, the cost of electricity only increases by about 0.06 mills/kwh per $1/lb increase in U_3O_8 price.

Thus, taking the U.S. Bureau of Mines' prediction of a $10/lb rise in price for the year 2000, it appears that the price of nuclear power from light-water reactors would rise by only about 0.6 mills/kwh. The total cost of electricity from a new nuclear plant is currently estimated to be about 8.6 mills per kwh. These estimates are taken from the report on Energy Research Needs described on pages 58 and 60.

exploitable reserves. The percentage of the resource base that will be converted into commercial reserves in the future depends on the state of technology and on the relationship between the price of the mineral and the cost of obtaining it. How can more be learned about the natural resource endowment and about the amounts of reserves that are likely to become available in the future at different prices?

5) How will the (probably) higher costs of obtaining greater quantities of, say, gaseous and liquid fuels from natural sources of crude oil and natural gas compare with the costs at which these energy forms can be made available from unconventional sources such as coal and shale through new technology? Correct decisions about investment in R&D on new conversion techniques cannot be made in the absence of knowledge of such comparisons.

6) To what extent will research and development in energy production and use enlarge the scope of trade-offs at all stages of the energy flow processes — from mineral exploration through energy conversion and ultimate use? R&D possibilities need to be studied not only to make choices among different lines of technological research, but also to understand better the broader range of supply and demand options that will become available.

7) What are the probable consequences for human health and ecosystems of the various pollutants associated with the flow of energy commodities through the economy. Research is required to reduce the area of uncertainty, to know what actions to take in the face of uncertainty, and to shape institutions in such a way as to reconcile citizen participation with efficiency in decision making and administration.

8) Government policies, those of long standing and those newly emerging, strongly affect the entire spectrum of activities within which future supply and demand balances will be struck. The presumed basis for government policies must be studied, but, more important, their effects, both intended and unintended, must be understood because energy shortages, so-called, can be as readily produced by misguided government intervention as by the failure of government to act.

Papers on many subjects were assembled. In addition, a background report on research and development in energy conversion and utilization was prepared by the Environmental Laboratory of the Massachusetts Institute of Technology. The study, by Hoyt C. Hottel and Jack B. Howard, professors in the Department of Chemical Engineering, provided the main basis for the discussion of these subjects within the report.

Within RFF, the major contributors were Sam H. Schurr, Hans H. Landsberg, Joel Darmstadter, and Milton F. Searl. In addition, Frederick Wells and Jan Zwartendyk made important contributions to the study.

Forum on Energy, Economic Growth, and the Environment

Much of the concern about environmental quality centers directly on the energy industries. Within energy processes there appears to be no link in the chain — from the exploration, development, and extraction of mineral fuel reserves through to the eventual consumption of energy in homes and the family automobile — that is free from damaging effects upon the environment.

In view of the close relationship between growth in energy use, economic growth, and environmental quality, and the need for greater public understanding of the issues involved, RFF in April held a public forum at which leading experts in each of the related fields presented papers and joined in the ensuing general discussion. The program was as follows:

I. On Economic Growth
   - "The sources and benefits of economic growth" — Walter W. Heller, University of Minnesota
   - "The environmental costs of economic growth" — Barry Commoner, Washington University

II. On Energy Growth and the Environment
   - "Possible impacts of environmental standards on electric power availability and costs" — Philip Sporn, retired President, American Electric Power Company, Inc.; consultant
   - "Possible impacts of environmental standards on petroleum availability and costs" — Richard J. Gonzalez, petroleum economics consultant
   - "Possible impacts of energy growth on land, water, and the urban environment" — Gordon J. MacDonald, member, Council on Environmental Quality

III. On Problems of Public Policy
   - "The problem of reconciling conflicting policy goals" — Edward S. Mason, Harvard University
   - "Possibilities for reconciling goals by way of new technology" — Glenn T. Seaborg, chairman, U.S. Atomic Energy Commission
   - "New goals for society?" — Kenneth E. Boulding, University of Colorado

Along with a background paper by Joel Darmstadter of the RFF staff, these research papers are now being prepared for publication as an RFF book.

Regulation of Natural Gas

Papers presented at an RFF seminar on the regulation of the natural gas–producing industry, held in October 1970, are being

edited for publication. The seminar was undertaken at the request of the Energy Policy Staff of the Office of Science and Technology of the Executive Office of the President. The subject itself had been identified as urgently needing study in a 1968 RFF staff report, *U.S. Energy Policies: An Agenda for Research,* which had been prepared in response to an earlier request from the Office of Science and Technology.

The book will contain ten papers dealing with the role of natural gas in future national energy patterns, interfuel relations, projected costs of alternative sources of gas, producer regulation from several viewpoints, structure of the industry, and the effects of price regulation on supply.

Keith C. Brown, associate professor of economics at the Krannert Graduate School of Industrial Administration, Purdue University, who was in charge of organizing the seminar, has written an introduction to the collected papers.

Petroleum Conservation Regulation

Stephen L. McDonald's book, *Petroleum Conservation in the United States,* was published in August 1971. The author gives a comprehensive explanation of the system by which differing state regulations govern specific stages in drilling and oil well operation, production controls, and well spacing. He surveys the regulatory approaches in all the significant oil-producing states and develops an economic framework for analyzing the system with a view to interpreting, evaluating, and proposing changes. The substitution of universal unitized operations for all restraining regulations — save those designed to prevent external damages — would, he believes, provide profit-motivated private enterprise, operating through the price system, with a better means of conserving oil and gas than does the present system.

The study was supported by an RFF grant to the University of Texas at Austin, where McDonald is professor of economics.

Structure of Selected Mineral Industries

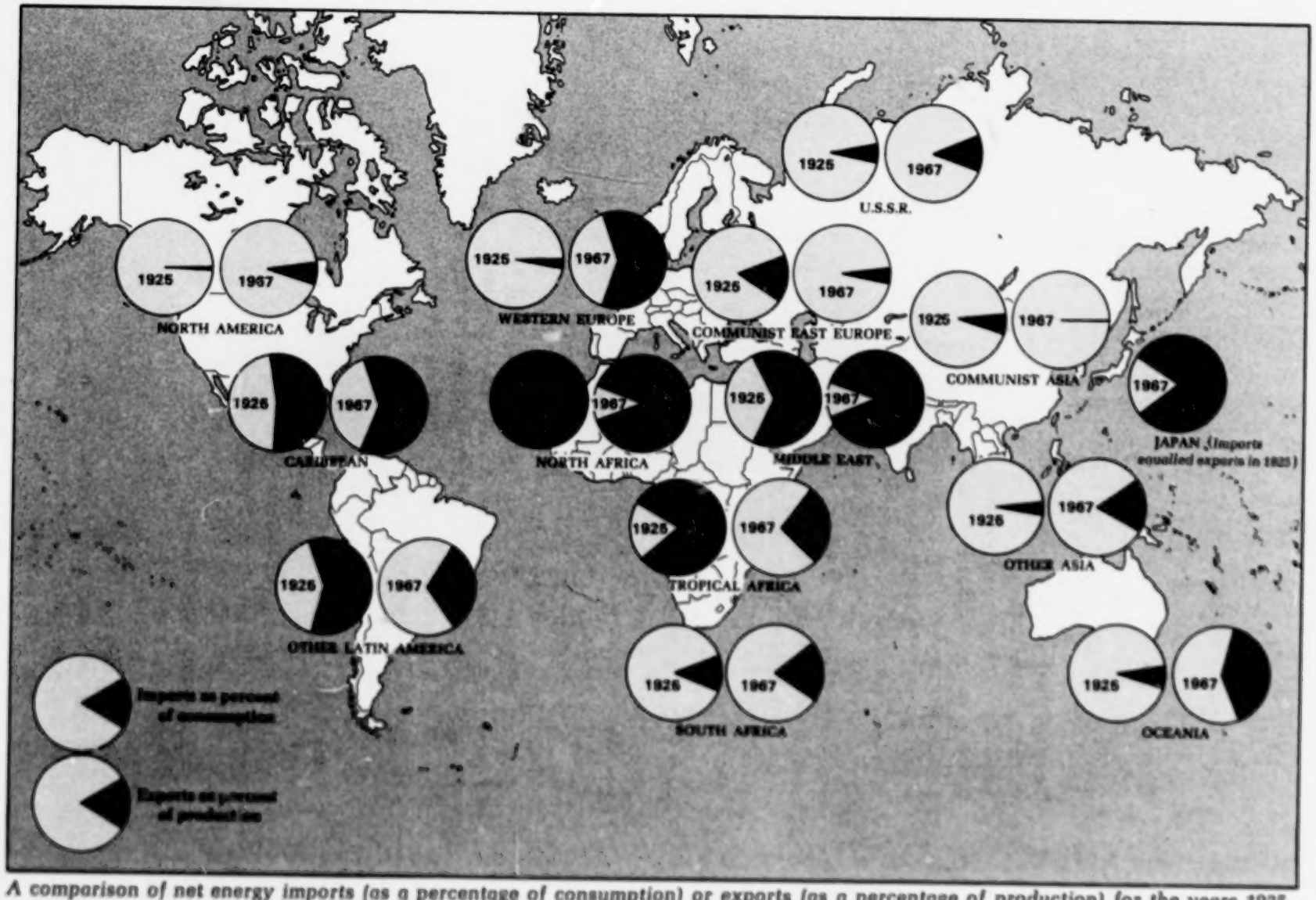
Understanding the structure of mineral industries is an essential element in providing an improved basis for many policy decisions. An RFF staff study begun this year is concerned with the distribution among firms of iron ore, copper, lead, and zinc mine production. The analysis of output distribution is being prepared for two widely separated years, 1968 and 1948/49, in order to give some indication of change over a substantial period of time. An attempt will be made to include all countries where output policies of mining firms are not subject to centralized governmental control. The research is being conducted by Orris Herfindahl with the statistical assistance of Elizabeth Vogely.

International Energy Studies

Middle Eastern Oil and the Western World: Prospects and Problems, by Sam H. Schurr, Paul T. Homan, and others, was published by American Elsevier Publishing Company in May 1971. This book is one of two books based on RFF research that have resulted from a joint RFF-Rand Corporation program specially financed by the Ford Foundation.

The Middle Eastern Oil study and a study of the world petroleum market by M. A. Adelman (being prepared for publication) lay the groundwork for a better understanding of the complex set of factors involved in the political economy of international oil. The Adelman study was supported by RFF grants to the Massachusetts Institute of Technology, where the author is professor of economics. He gives a comprehensive treatment of the basic economic forces at work in the world oil industry within which the intricate three-cornered relationship among producer countries, international companies, and importing countries must eventually be resolved. The Schurr-Homan study deals with company-government relationships but reaches also into the troublesome problem of supply interruptions and the difficulties and policy problems they pose for both exporting and importing countries. The issues dealt with in the two studies surfaced during the past year when tax and price negotiations took place between exporting countries and the international oil companies, and the threat of an embargo on oil shipments accompanied the negotiations. These events did not write a finish to the problems. Negotiations on prices and taxes can be expected to resume their stormy course in the years ahead, and additional questions — centering on the determined effort of producing governments to obtain ownership participation in existing concessions — will join the list of disputed issues.

Energy in the World Economy, by Joel Darmstadter, with Perry D. Teitelbaum and Jaroslav G. Polach, will be off the press by the end of 1971. A number of years of staff effort in assembling, organizing, and interpreting basic data have resulted in this comprehensive volume on long-term trends in energy consumption, production, and foreign trade since the 1920s. A central concern of the study is to show how during this period the world's fuel base shifted away from coal and toward oil and natural gas. This change, which occurred at different times and rates in the major geographic regions, is important for two reasons: it reflected, as well as facilitated, significant changes taking place in the world's industrial life and in economic activity in general; and it gave rise to wholly new patterns of regional economic interdependence. This interdependence is seen most sharply in the strong



A comparison of net energy imports (as a percentage of consumption) or exports (as a percentage of production) for the years 1925 and 1967 indicates the extent to which a region has become more dependent on energy imports, or has achieved greater surplus capability for exports. The chart is based on data from **Energy in the World Economy.**

reliance of industrial countries such as Japan and those in Western Europe on petroleum imported largely from less-developed regions such as the Middle East and North Africa.

In reviewing these developments, the book first presents statistical series depicting movements in consumption, production, and international trade of energy commodities since 1925 by countries, regions, and the world as a whole. The voluminous statistical materials are condensed to bring into focus the main features of the movements. The book relates these main features to other economic variables and, in so doing, provides a springboard for evaluating future prospects.

International Mineral Studies

Two books that trace recent developments in the world's mineral industries were published during the year. *Foreign Investment in the Petroleum and Mineral Industries,* by Raymond F. Mikesell and associates, presents twelve case studies of situations where foreign ownership of mineral resources is subject to changing political and economic climate. The studies, ten of which deal with Latin American countries and two with Middle Eastern countries, are introduced by chapters outlining the general issues involved. A concluding chapter suggests that as time goes on foreign investors are likely more and more to act as sellers of their special services at competitive market prices rather than as owners free to maximize returns to the parent companies.

The Changing World Market for Iron Ore, 1950–1980: An Economic Geography by Gerald Manners deals with the sweeping changes in the spatial market for iron ore and steel that have taken place over the past twenty years, and assesses their implications for the future of the world iron ore industry. Since 1950, iron and steel production in the Soviet Union has slowly approached the U.S. production level, and Soviet ore production is now considerably larger than U.S. output. Japan has become the third largest center of iron ore demand, and Australia recently has become one of Japan's major suppliers. Manners estimates that by 1980 the market will have grown fivefold over the 1950 level. A supplement to this book, dealing on a country-by-country basis with the spatial distribution of the iron and steel and the iron ore industries between 1950 and 1965, is available in Xerox manuscript form under the title *The Changing World Market for Iron Ore: A Descriptive Supplement Covering the Years 1950–1965.* [See page 94.]

Both books result from research supported by RFF grants: the former to the University of Oregon, where Mikesell is W. E. Miner professor of economics, and the latter, including the supplement, to the University College of Swansea. Manners is now Reader in Geography at University College London, University of London.

Problems of Mineral Exporting Countries

Zuhayr Mikdashi, professor of business administration at the American University of Beirut, and author of several studies on international oil, is undertaking a study of the problems of mineral exporting countries.

The management of mineral resources in such countries has many dimensions. Mikdashi is confining his attention to those aspects that figure importantly in international trade in bauxite, copper, iron ore, petroleum, and tin. He proposes to examine various forms of intervention that governments and enterprises of mineral exporting countries have exercised or could exercise — acting individually or in groups — to take advantage of world-market opportunities.

Mikdashi has received a research grant from the Ford Foundation through its office in Beirut. RFF is providing him office space and secretarial and other ancillary assistance.

Regional and Urban Studies

RFF's program of regional and urban studies is organized around problem clusters concerned with (1) the relationships among cities — a focal point in the current movement toward a national urban growth policy; (2) the internal organization of cities, especially those problems that are associated with density; (3) the management of large urban complexes and the reform of the governmental structure of metropolitan regions; and (4) the rapid rates and concentrated forms of urbanization being experienced in developing countries.

In the 1970-71 program year progress was made in several projects begun a year or more ago. Some were completed. Others, of longer term, will not yield results until at least 1973, when it is expected that we shall be able to draw together and integrate the contributions these projects will have made to an understanding of the processes of urbanization.

NATIONAL URBAN DEVELOPMENT STRATEGIES

A signal event of the program year was a conference conducted jointly by RFF and the University of Glasgow that brought together British and American economists whose concern is with policy and analysis deriving from both countries' experience with urban and regional development. The fact that the British have been experimenting with strong urban and regional development policies for well over a generation provided the conference with a broad, empirical base for the discussion of national urbanization policy — a matter that has become a recurring theme on the American political scene in the last two years. At the same time, the recent rapid advancement of urban economics as a subdiscipline in the United States contributed an important element of theory, methodology, and insight to the five-day discussions.

The Conference on Economic Research Relevant to National Urban Development Strategies, held in Glasgow from August 30 to September 3, was organized and managed by Lowdon Wingo of RFF and Gordon Cameron of the University of Glasgow's

Department of Social and Economic Research. It was financed by Resources for the Future, the Ford Foundation, the University of Glasgow, and by the contributions toward travel costs of several private organizations.

The conference met in the six sessions listed below. Each was organized around a special topic, which was discussed by a British and an American moderator.

Welfare Implications of National Settlement Patterns
Chairman: Harvey S. Perloff
Moderators: I. C. R. Byatt, Department of the Environment; Edgar M. Hoover, University of Pittsburgh

Welfare Implications of Internal Organization of Metropolitan Regions
Chairman: Sir Robert Greive
Moderators: J. M. W. Stewart, University of Kent; Ira C. Lowry, The Rand Corporation

Public Finance Issues of National Settlement Patterns
Chairman: Harold Hochman
Moderators: Alan Williams, Centre for Administrative Studies; Dick Netzer, New York University

National Economic Development and the National System of Cities
Chairman: S. C. Orr
Moderators: T. Wilson, University of Glasgow; Michael F. Brewer, Resources for the Future

National Objectives and the National System of Cities
Chairman: Sam Rosenblatt
Moderators: R. Pahl, University of Kent; Anthony Pascal, The Rand Corporation

The Organization of Government to Implement Urban Development Strategies
Chairman: S. G. Checkland
Moderators: Peter Hagger, Department of the Environment; Francis D. Fisher, consultant to U.S. Department of Housing and Urban Development

Organizational and terminal meetings were chaired by Professor L. Hunter of the University of Glasgow and Joseph L. Fisher of RFF; and a special meeting was held to discuss a paper, by Marion Clawson of RFF and Peter Hall of the University of Reading, on urban expansion in the United States and Great Britain.

Of the eighteen papers that provided the background for conference discussion, six were products of work done or supported by RFF. Institutions responsible for other papers were the Centre for Environmental Studies in London, the Urban Institute, the National Planning Association, and the Department of Social and Economic Research of the University of Glasgow. The papers are listed on the next page.

James Douglas McCallum — A review history of British regional policy

Lowdon Wingo — Notes on a national urban development strategy for the United States: Politics and analytics

Wilbur Thompson — The national system of cities as an object of public policy

H. W. Richardson — Optimality in city size, systems of cities, and urban policy: A sceptic's view

Joel Bergsman, Peter Greenston, and Robert Healy — The agglomeration process in urban growth

Edwin S. Mills — Welfare aspects of national policy toward city sizes

Alan W. Evans — The pure theory of city size in an industrial economy

Gordon C. Cameron — Economic analysis of a declining urban economy

Bruce D. Phillips and Wilfred Lewis — Test of small area population forecasting system: A guide to understanding the determinants of migration

Benjamin Chinitz — The pattern of urbanization within regions of the U.S.

Christopher Foster — Public finance aspects of national settlement patterns

Gavin McCrone — Location of economic activity in the United Kingdom

Irving Hoch — Income and city size

P. A. Stone — The economics of the form and organization of the city

Jerome Rothenberg — Abstract: A model of intra-metropolitan location and growth

David Eversley — Diseconomies of urban scale or wrong administrative framework?

David Donnison — Urban objectives

Richard P. Burton — On the relevance of governmental reorganization to national urban growth policy

The papers will be published in two special issues of the international journal *Urban Studies*. Meanwhile Wingo and Cameron are preparing an appraisal of the status and problems of national urban development strategies, based on the conference discussions.

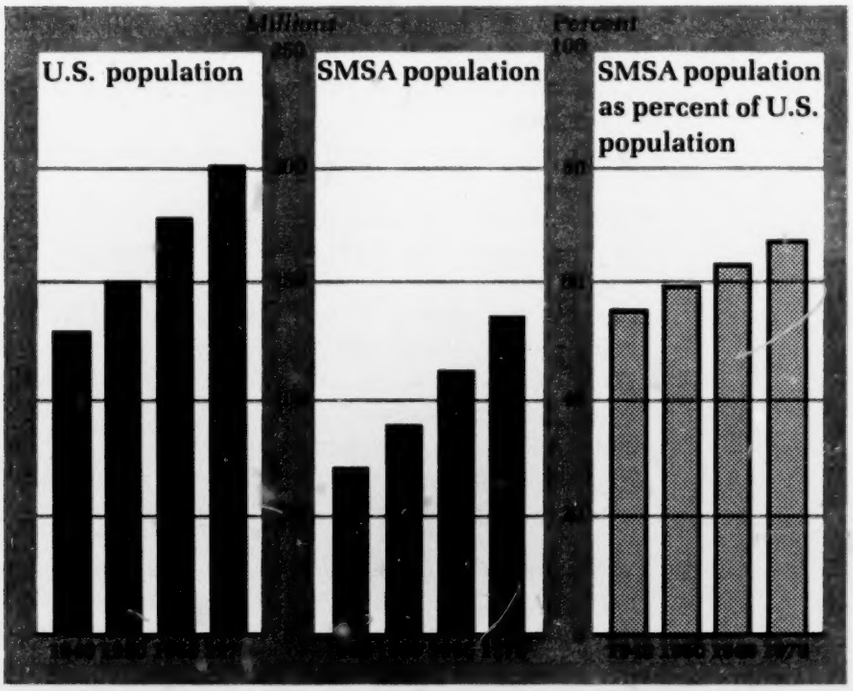
Four of the papers drawing on current RFF-sponsored research are described below.

Determinants of City Sizes in a National System

The paper by Alan W. Evans was based on research undertaken last year under RFF grants to the University of Glasgow. Evans is seeking to identify the extent to which the frequency of city sizes in a national system is rigorously determined by character-

istics of the national economy and, if this indeed is so, to find out what main variables are involved. Scholars concerned with urbanization have characterized national urban systems in terms of hierarchies of functions and in terms of a size distribution described by the so-called rank-size rule. This rule posits that the approximate size of any city in an urban system is some function of its rank and the size of the largest city in the system.

Such constructs are useful as descriptive devices, but they do little to explain key relationships in the urbanization process. Evans's paper proposes an analytical approach based on the structure of costs in urban areas of various sizes and on an application of the theory of clubs or coalitions. Cities grow by the accretion of firms making optimal location decisions among cities in a system, where their expected returns vary with city size, but each firm's choice tends to make its destination city larger. This, in turn, results in a situation where some firms, finding the new city size too large, seek out smaller cities where



Demographic data since 1940 show a remarkably steady rate of growth in the proportion of people living in the 212 Standard Metropolitan Statistical Areas (SMSAs) of the United States, although the general rate of increase in urban population has been decelerating since the period of rapid industrialization which reached its peak around 1930. The SMSA, a census category, consists usually of one central city with a population of 50,000 and of surrounding counties that are metropolitan in character. It is one of the basic measures used by Mills in his Studies in the Structure of the Urban Economy, *mentioned on page 72.*

their operations are more profitable. Meanwhile other firms, with greater economies of scale, are able to thrive upon the opportunities offered by the new city size. With technology and size of the nation given, a specific population of firms will form and reform coalitions until an optimal distribution results, and this will be shown in a unique rank-size distribution. Thus, a key relationship in the urbanization process is the locational choice of firms among cities based on maximized returns.

Regional Patterns of Urban Structure in the United States

The paper written by Benjamin Chinitz is, in effect, an interim report on RFF-supported research begun at Brown University in 1970. Its chief objective is to determine if the development of a region in the United States can be related to the patterns of urbanization exhibited at various stages in regional development. From his first look at the data from the censuses during the period 1900–1960, Chinitz has tentatively concluded that differences in regional levels of urbanization are associated with differences in economic structure. The relationships are frequently lagged over considerable periods; indeed, the relationship between the share of the labor force in agriculture and the share of the rural population in total population reflects a lag of some thirty years. There is reason to believe, he suggests, that not enough people live in cities, given the size of the agricultural labor force and the size of rural populations in all regions — a finding that is inconsistent with the strong political movement for population distribution and with public policies hospitable toward the nation's rural areas.

Urban Externalities and City Size and Structure

Edwin S. Mills's research, which is supported by a 1970 RFF grant to Princeton University, was barely under way at the time of the Glasgow conference. Nevertheless, his paper reflected some tentative conclusions about the interrelationship between urban organization and such negative externalities as congestion, pollution, and environmental degradation generally, and the higher costs of rendering public services. Mills suggests that such externalities may have little direct effect on the size of cities; their major impact would appear to be on the way in which cities organize themselves internally. If this is the case, excessive political concern with altering the size of cities may be misguided, for the real social gains may lie in the improvement of incentive systems that allocate the costs of these externalities to those who generate them. Mills's project has another year to run and will involve extensive empirical analysis to enrich theoretical speculation about the impacts on the structure of the city of compensatory charges for the production of externalities.

Mills's previous research, dealing with characteristics of U.S. urban systems, has resulted in *Studies in the Structure of the Urban Economy*, to be published for RFF in the spring of 1972. In exploring the ways that private markets determine urban structure in the U.S. economic setting, Mills focuses on aspects of urban area decentralization, which has been in progress for many decades. He first surveys the broad outlines of urban growth and structure in the United States and examines the pattern of land use intensity for residential and employment purposes. Later, Mills uses several theoretical models to analyze both positive and normative aspects of market performance, to study the relationships between residential location and commuting, and to present an idealized system that fulfills the conditions of economic efficiency. Comparison between the models suggests what effects a policy of efficient investment and pricing in urban transportation might have on the pattern of urban residential density.

Income, City Size, and Urban Space Use

Irving Hoch's paper reported on his current research at RFF to do with the relation of income and amenity to urban size, density, and form. Hoch notes evidence that in all four major census regions wage rates for a homogeneous population increase with city size; that the cost-of-living increases with city size as well, but that a substantial differential in per capita income remains after adjustment for cost-of-living differences. He believes that this differential may reflect declining net amenity with city size and density. This often involves important externalities — pollution, congestion, crime, and other social problems — but he indicates that caution is needed in interpretation: crime, for example, is associated with city size, but the city size effect in turn reflects demographic factors, particularly of race and age composition.

Hoch's study of income and city size is closely tied to his continuing research into the economics of urban space use. Pollution, congestion, and crime affect the way people and property values are distributed within cities as well as between cities.

Hoch's research is being extended in a report, "Urban Size, Density, Form, and Environmental Quality," which is part of the study RFF is making for the President's Commission on Population Growth and the American Future. Air pollution, water pollution, noise, and solid waste disposal are being examined for their relation to city size, density, and form; other environmental impacts of city size — climate and hydrological effects — are also considered.

The Changing Structure of the U.S. Urban Hierarchy

A statistical study initiated a few years ago by Edgar S. Dunn seeks to identify and analyze developmental changes taking place

in the urban structure of the United States. This work, completion of which was deferred until the release of 1970 census materials, is now being resumed. The additional material will allow the project to extend by a decade the transformations subject to study, and will provide a better test of the persistence of some of the regularities observed. Data for counties, nodal economic regions, and metropolitan areas will all be processed in an effort to sift out significant patterns of change. The by now familiar shift-share analytical technique will be given some novel applications and other forms of transformation matrixes will be employed. One such application attempts to assay the importance of the relationship over time between the structure of central place activities and changes in urban size. The object will be to identify, if possible, developmental paths characteristic of different kinds of urban regions and different stages of urban development. This study will inquire whether the historical record will support any generalizations about the developmental options of urban regions.

The Concept of the Urban System

Dunn is also at work on a study in which he attempts to clarify the concept of the "urban system." This, he believes, will help to integrate existing areas of urban research and to identify areas that need more attention. First, he will examine the urban system as a network of the patterns developed in functional and geographic space by the transfers of goods, people, and information between households, enterprises, governments, and other social systems. These networks can be further subdivided into flow networks and boundary networks. A paper, "A Flow Network Image of Urban Structure," published in *Urban Studies* in October 1970, is an early product of this part of the research. At a later stage, Dunn, viewing the urban system as a control system, will specify the ways in which, as such, it differs from conventional images of control systems. Here, research will be focused chiefly on the degree to which information processing identifies and shapes the component systems of the urban complex and the extent to which information processes for regulating the externalities become public responsibility.

THE GOVERNANCE OF METROPOLITAN REGIONS

In 1970 RFF sponsored a Commission on the Governance of Metropolitan Regions, which is concerned not only with the apparatus and process of government, but also with the total interaction of people in their public capacities and interests and between people and the public institutions. Charles M. Haar of the

Harvard Law School, and an RFF Associate, assisted in setting up the Commission and serves as its chairman. Several meetings have been held and a number of papers commissioned. Ten of them will be published early in 1972 in three small volumes as the first items of a series on "The Governance of Metropolitan Regions." At year's end several other papers were being revised for later publication as one or two further volumes in the series.

A second phase of the Commission's work will concentrate (1) on the relationships between major metropolitan problems and the organization of government, and (2) on ways and means of interpreting and disseminating to the public and to policy makers alike the findings of research that may assist in the reform of governmental institutions in U.S. metropolitan areas.

The titles and contents of the three books that are being prepared for publication are listed below.

Reform of Metropolitan Governance: Expectation and Realities

1. Steven P. Erie, John J. Kirlin, and Francine Rabinowitz — "Can something be done? Propositions on the performance of metropolitan institutions"
2. Lance Liebman — "Metropolitanism and decentralization"
3. Charles M. Haar — "A federal role in metropolitanism"

Minority Perspectives

1. Dale Rogers Marshall — "Metropolitan government: Views of minorities"
2. Bernard J. Frieden — "Blacks in suburbia: The myth of better opportunities"
3. Daniel W. Fessler — "Litigation and the dynamics of unanticipated change"

Metropolitanization and Public Services

1. John G. Wofford — "Transportation and metropolitan governance"
2. David L. Kirp and David K. Cohen — "Education and metropolitanism"
3. Leonard J. Duhl — "A new look at the health issue"
4. Edwin T. Haefele and Allen V. Kneese — "Residuals management and metropolitan governance"

MECHANISMS OF SOCIAL CONTROL

Information as a Resource

Edgar S. Dunn has been identified for some time with issues related to the development of information systems. He was engaged in this activity while an official in the U.S. Department of Commerce. After joining RFF he served as a consultant to the Bureau of the Budget in an evaluation of proposals for the establishment of a national data bank. He has written several papers devoted to this topic and served on the advisory board of the

National Academy of Science's study of computer data banks. This year he is preparing a study in which he will describe and evaluate various strands of the statistical reform movements and their relationship to the controversial issue of personal privacy. In doing so he will focus upon the design issues that are implicit in statistical reform. He will also examine the roles that information plays in complex social systems, emphasizing their character as the fundamental resource of the social process.

Economic and Social Development

Last winter Dunn's *Economic and Social Development: A Process of Social Learning* was published as an RFF book. Dunn compares the evolution of social learning with its antecedent learning process, biological evolution. Many of the same characteristics are shown to be common to both, but the great difference is that social learning is capable of generating individual and group behavior that can itself purposively change behavior. Some aspects of social learning have become formalized and codified in classical science; consequently, social learning has been applied more efficiently in the realm of physical science and the design of physical systems than in the realm of social organization and change. Dunn maintains that in the realm of social systems the rules of classical science are not adequate to specify the essential learning process and need to be supplemented by a more generalized process characterized as evolutionary experimentation.

URBANIZATION IN DEVELOPING COUNTRIES

For more than a year RFF has cooperated with the Economics of Urbanization Division of the World Bank to develop a joint program of research on the policy problems of urbanization in developing countries. Some phases of this effort were substantially advanced during the summer when Richard M. Westebbe, an economist with the Bank, took three months' leave to join with Lowdon Wingo in a study of urban management problems in such countries, and especially of appropriate ways in which international lending agencies can help countries cope with rapid urbanization. The study draws heavily on documentation gathered by earlier Bank missions in several developing countries. This and other relevant data have been made available to RFF from the Bank's research files.

Appraisals and Special Projects

Several projects conducted or sponsored by Resources for the Future are administered separately from the major categories of research dealt with elsewhere in this report. Some are an outgrowth of RFF's eight-year-old appraisal of resource adequacy in the United States. They deal with situations where sufficiency of resource supply may be in question or where technology has opened up new possibilities in the use of a resource. Other projects relate to RFF's new population-environment studies and to our continuing studies of marine resources. A few are extensions of RFF's educational function — an integral part of each of its research programs.

RESOURCE APPRAISALS

Since publication of RFF's *Resources in America's Future* in 1963 no one has attempted an equally comprehensive appraisal of overall resource adequacy in the United States, although there have been several studies of individual sectors of the economy. Early in the program year RFF embarked upon a limited updating of its original broad study, with 1970 replacing 1960 as the base year. A research agreement was entered into with Economic Associates, Inc., whose president, Leonard L. Fischman, collaborated with Hans Landsberg and Joseph Fisher in the 1963 study. Draft material on which an abridged, revised version could be based was received in August. Landsberg is now reviewing this work and cooperating in its use as a contributing element in the population-environment study described below under "Special Projects."

Preparation of the new material involved much more than a mechanical updating and organization of the material for computer operation. Since some of the statistical series used in the original study were discontinued or underwent major changes in the sixties, substitute series had to be developed and linked to the past. The abridged version could not retain all of the detailed statistical breakdowns that characterized the 1963 study, and some

series had to be eliminated. Before setting up the new project for computer operation, the technical coefficients were checked by reexamining the relationships between different time series — between the number of persons over twenty years of age and the stock of passenger automobiles, for example, or between aluminum tonnage produced and electricity consumed in producing it. With the computerized programming of such data and their relationship, it should be easier in the future to introduce specific revisions or to hypothesize changes in crucial items and trace the results. Analyses will be made of the principal findings, including projections to 2000, and a comparison of the differences between "1970 as projected in 1960" and "1970 actually."

Changing Technology in Iron and Steel

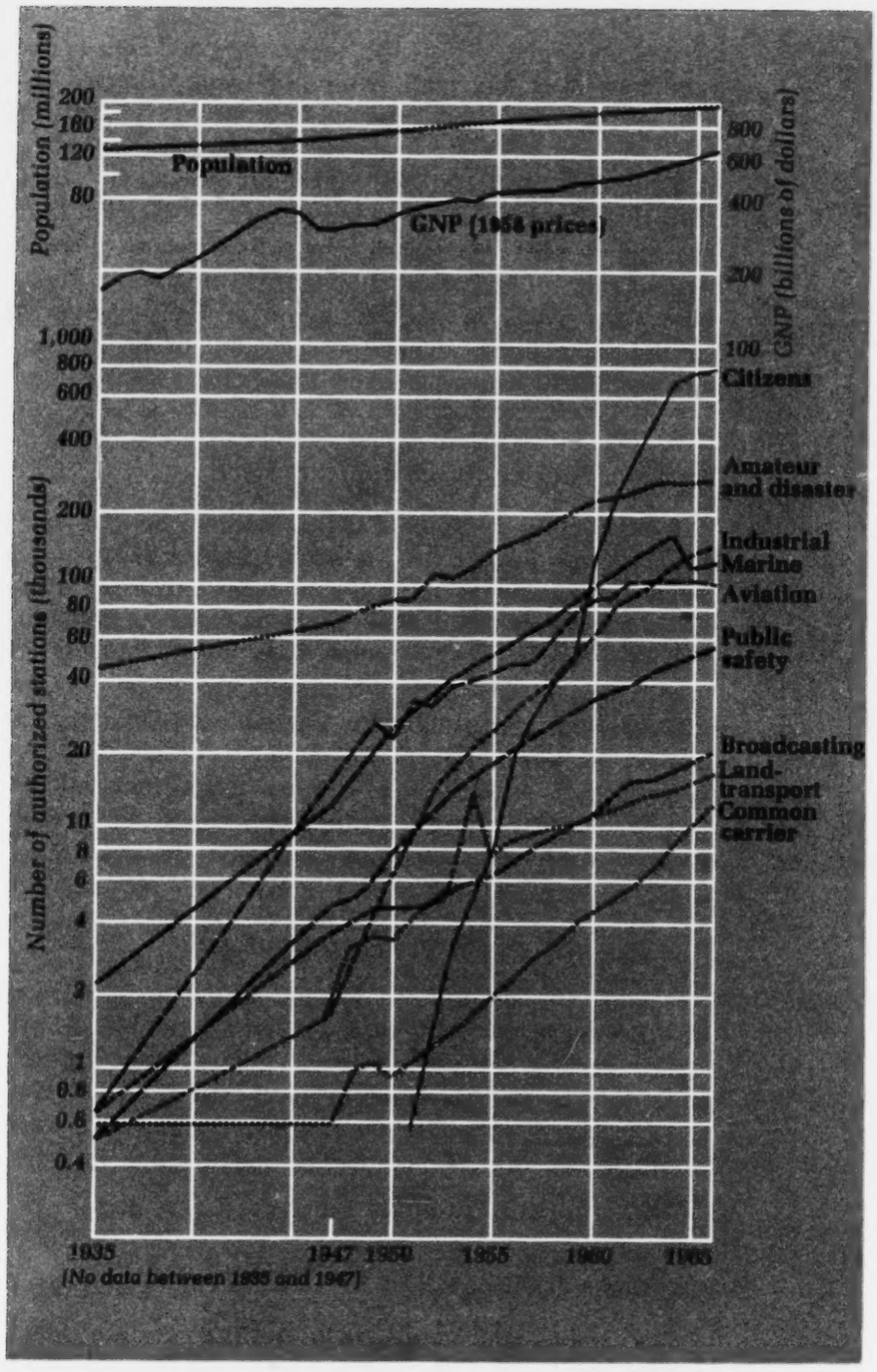
In September 1971, Bela Gold, William S. Peirce, and Gerhard Rosegger, professors in the Department of Economics at Case Western Reserve University, submitted a draft manuscript reporting on their grant-supported study of technological change in iron and steel manufacturing since 1900. In tracing the changes that have taken place and analyzing their effects on both physical and economic performance in coal and iron mining, coke and iron production, and primary steelmaking, the authors have produced a report that is not only of interest in its own right but one that should contribute to the further refinement of several aspects of the resource projection work discussed above.

The Economics of Materials Substitution

A staff study has been begun on the economics of materials substitution in the context of different availability horizons, physical properties, and applications. This will draw on the preliminary work done by Joel Darmstadter in cooperation with Harold Goeller of Oak Ridge National Laboratories. Frederick J. Wells, who recently joined the RFF staff, will spend most of his time on this project.

The Radio Spectrum

The radio spectrum — that portion of the electro-magnetic waves by which information is transmitted through the air — presents mounting problems of allocation as use increases and congestion, or interference, becomes more severe. In *The Invisible Resource: Use and Regulation of the Radio Spectrum*, Harvey J. Levin, Augustus B. Weller professor of economics at Hofstra University, analyzes the economic characteristics of the radio spectrum, which is a resource of great economic and social value but in whose allocation market considerations play almost no part.



The rate of growth in authorized radio stations is one indication of the mounting problems in allocating use of the radio spectrum—the subject of The Invisible Resource *mentioned on page 77. The chart shows the vigorous growth between 1935 and 1947 of such services as marine, aviation, public safety, industrial, and broadcasting — a result of wartime breakthroughs and pent-up demand — and the later swift growth of common carrier, land transport, and citizen services.*

Engineers and technologists normally prevail in the basic allocational field, and lawyers and public administrators have long dominated the licensing and regulation of public and private users of the spectrum. Levin describes and evaluates the goals, policies, and performance of the American system of interacting spectrum users, managers, and developers; discusses procedures and institutions that might be feasible alternatives to the present regulatory machinery; and suggests that the most practicable course in this country may lie somewhere between the present system and a full-fledged market for the spectrum.

Levin's research was supported by an RFF grant to Hofstra University.

SPECIAL PROJECTS

Population Studies

During the program year an investigation of future relationships between population growth, economic growth, and the environment was initiated at RFF at the request of the President's Commission on Population Growth and the American Future. The overall goals of the project are to (1) forecast the dimensions and nature of the resource and environmental problems that the nation is likely to face in the year 2000; (2) determine the extent to which changes in population, patterns of consumption, and technology respectively contribute to these problems; and (3) suggest ways of handling the major problems. Ronald Ridker is directing the project.

The general approach is to develop several sets of plausible assumptions about the future, the principal variants being population growth and geographic distribution, standard of living, and technological possibilities. The assumptions are being examined in two ways: first, by constructing a comprehensive model, which permits the speedy simulation of a wide variety of alternatives; and, second, by conducting a series of special studies to investigate key sectors and issues in greater depth. Studies of recreation needs, energy supplies and demands, the relationship between population density and urban problems, and resource adequacy and substitutability have been undertaken at RFF by Charles Cicchetti, Joel Darmstadter, Irving Hoch, and Hans Landsberg; and reports on the role of agriculture, the economics of recycling, and on ecological implications are being prepared under research agreements with the Agricultural Research Service of the U.S. Department of Agriculture, The Center for the Environment and Man (where Frank Smith is the principal researcher), and Fred Smith of the Harvard School of Design. Information yielded by the analytical work on residuals management being done under RFF's quality of the environment program further contributes to the project.

Consumption coefficients and projections for public expenditures used in the model were developed by Ridker and Henry Herzog. Other work on the model is being done under research agreements with the International Research and Technology Corporation and Economic Associates, Inc. (see appraisals program). An interim report was submitted to the President's Commission in May, and a final report is scheduled for January of 1972.

In order to contribute to and learn from the research being done by others concerned with demographic-environmental problems, RFF jointly with the Population Council arranged for a series of one-day seminars to discuss problems and findings in areas of research that are of mutual interest. The seminars began in May and were scheduled to conclude in January.

"To Live on Earth"

The sudden rise of public concern over man's relationship to his environment is one of the most striking phenomena of recent years. Although emotions run high and opinion strong, many of the basic facts are in dispute or still unexplored. When is it prudent to act on partial evidence, and when to wait? Can current levels of popular interest be maintained if some of the prospects turn out to be gray instead of black and white? Is it necessary to make a flat choice between environmental quality and economic growth, which less than a decade ago was looked upon as the answer to many of the nation's and the world's ills?

An RFF study that seeks to put the many-sided problem of the environment in perspective was completed during the program year: *To Live On Earth,* by Sterling Brubaker. Avoiding technical language, the study is designed primarily for students and general readers. It draws heavily upon recent research by RFF staff members and grantees and, in some specialized fields, upon outside sources.

In addition to giving the background of the principal forces at work — notably population, economic activity, and technology, and the burdens they impose upon water, land, and air — the study classifies environmental threats according to their gravity, ranging from aesthetic nuisance to genetic damage and hazard for the earth's whole life-support system. It also surveys the prospects for dealing with environmental problems in the next few decades and over the longer future. Brubaker concludes that the outlook for the near term is generally favorable, but that the long-run prospects are much more dubious and will call for far-reaching adjustments in institutions and ways of thinking.

The book will be published early in 1972 by The Johns Hopkins Press and soon after in a paperback edition by the New American Library in its Mentor series.

Marine Resources

The growing trend toward more extensive national fishery limits and the call for a third United Nations Conference on the Law of the Sea, to be held in 1973, were among the more important developments relating to international marine resources during the year. These events, which point to significant changes in international arrangements for high seas fisheries, have prompted RFF to focus its current research on issues that are likely to be discussed at the UN conference. William T. Burke of the School of Law, University of Washington, who, under an RFF grant to the University, has been conducting a long-term study of fishery arrangements, is investigating the issues posed by these new developments. He has reported on some of the possible effects in "Some Thoughts on Fisheries and a New Conference on the Law of the Sea" (Occasional Paper No. 9, Law of the Sea Institute, University of Rhode Island, Kingston, R.I., 1971). Burke and Francis T. Christy, Jr., are also collaborating on a background study of fishery arrangements and problems that is designed to facilitate analysis of the issues likely to be raised in 1973. Future plans are still tentative, but consideration is being given to case studies of trends, developments, and alternative arrangements in specific fisheries.

The law of the sea for seabed minerals has also been undergoing change. During the year, L. F. E. Goldie, professor of law at Syracuse University, continued his work on this subject. He presented a paper, "The United States Draft for a United Nations Convention on the International Seabed Area," at the annual meeting of the American Society of International Law. And he published the following papers: "The North Sea Continental Shelf Cases — A Ray of Hope for the International Court," *New York Law Forum*, vol. 16, no. 2 (1970), and "The Continental Shelf's Outer Boundary — A Postscript," *Journal of Law and Maritime Commerce* (October 1970).

Recent Trends in Natural Resource Commodities

In some of RFF's early studies of the question of economic scarcity of natural resources within the United States, much of the analysis was based on the historical statistics in *Trends in Natural Resource Commodities*, by Neal Potter and Francis T. Christy, Jr. This book, published in 1962, provided uniform statistical series on prices, output, consumption, foreign trade, and labor for almost all natural resources used in the United States. The individual series were aggregated and deflated to produce indices of the relative importance of natural resources to the rest of the economy, and the study covered all years from 1870 through 1957.

An investigation of changes in trends since 1957 is being carried

out at Michigan State University, where Robert S. Manthy, associate professor in the Department of Forestry, is directing an effort to update the Potter-Christy series through 1968. Data for the entire 99-year period, together with index weights and deflator series, are being transferred to computer cards as a means of facilitating aggregation of the series and an analysis of trends. To support some additional work on the series and an analysis of the results by Manthy, RFF made a grant of $2,500 to the University this year.

Interrelationships Among Outdoor Recreational Demands

For the past two years a research team at the Natural Resources Policy Center, The George Washington University, has been seeking to determine the degree to which changes in the use of an outdoor recreation area are affected by changes in the availability and attractiveness of facilities located at competing sites.

The research, done under a grant from Resources for the Future, concentrated on eight Corps of Engineers reservoirs located in the Dallas–Fort Worth area of Texas. Comparisons among them were made with regard to such variables as provision of facilities, extent of overnight accommodation, accessibility to centers of population, attendance levels and characteristics, quality of the area, and fees charged.

In June the Center presented the results of its research in a mimeographed report, "Determinants of Recreational Use at Eight Corps of Engineers Reservoirs in the Dallas–Fort Worth Area," by Mary A. Holman, associate professor of economics at the University and until recently acting director of the Center, and James T. Bennett, assistant professor of economics.

RFF Fellowship Program

During 1970–71, the eleventh year in which RFF has conducted its resources fellowship program, eleven fellowships were awarded to doctoral candidates whose dissertations will involve the application of the social sciences to natural resource problems:

Richard N. L. Andrews, University of North Carolina — Functional planning and the environmental quality objective in selected federal agencies

David de Ferranti, Princeton University — Transportation and urban structure

Riley E. Dunlap, University of Oregon — Political pluralism and environmental issues: The impact of "non-decisions" on environmental policy in Oregon

John Kuiper, Stanford University — Economic planning of hydro power systems with multipurpose applications

Peter Hin Pung Ho, Carnegie-Mellon University — Demand analysis for urban riverine recreation

Donald MacMillan, University of Montana — A history of air and water pollution in Montana

Richard H. Mead, Harvard University — A methodology for public policy decision making: Choosing between additional electrical generating capacity and cleaner air quality

Frederick M. Peterson, Princeton University — Optimum use of depletable natural resources

George W. Silverthorne, University of California, Santa Barbara — Optimal production from a seaweed resource

Stephen W. Sorensen, University of Texas — Coalitions and competition in resource development: "Fair" allocation of costs and benefits in river basin development

Robert M. Spann, North Carolina State University — The supply and demand of oil and gas discoveries and production in the U.S.: A simultaneous equation approach

Fourteen RFF Fellows of previous years presented dissertations to their universities in partial fulfillment of the requirements for the degree of Doctor of Philosophy. The theses are listed below:

Francis Joseph Convery, Syracuse University — Impacts of alternative rural land-uses: A case study

James Connor Cox, Harvard University — Essays in economic theory

Richard Verr Eastin, University of California, Santa Barbara — An entropy maximizing model of urban residential location

David Elias Euresty, Pennsylvania State University — A systems approach to the regional evaluation of potential mineral resources using computer simulation, with a case study of the impact of infrastructure on potential supply of base and precious metals of Sonora, Mexico

Dae Kyoon Kahng, University of Oklahoma — An econometric study of production technology

Ronald G. Lorentson, University of Washington — Temporal production interdependency in agriculture arising from water quality

R. W. Pearson, University of Illinois — Resource management strategies and regional viability: A study of the Great Slave Lake region, Canada

David Eldon Pingry, Purdue University — Programming applications to the economic problems of water quality control

Jeffrey Mel Romm, Cornell University — Nuclear power, Cayuga Lake, and economics

Thomas Reynolds Stauffer, Harvard University — The measurement of corporate rates of return and the marginal efficiency of capital

Norman Philip Swenson, Washington University — An economic analysis of federal timber marketing policies in southeast Alaska

William Downing Watson, Jr., University of Minnesota — Costs of air pollution control in the coal-fired electric power industry

Frederick John Wells, Massachusetts Institute of Technology — An economic evaluation of the U.S. desalting research and development program

Stephen Hughes Zeller, Boston College — The urban firm's production-location decision: Towards a theory of land and property taxation

Latin American Program

For most of the economically less-developed countries of the world the use of their natural resources is important not only in building their domestic economies but also in earning needed foreign exchange. Over the past seven years, RFF has sought to make its expertise available to these countries, concentrating in particular on Latin America.

RFF's program of work on Latin American problems has a dual focus: it generates research in the field and at the Washington office on resource and urbanization problems in the context of Latin American development; and it attempts to stimulate interest and improve research capacity on resource problems in Latin American countries through teaching and collaboration with local scholars.

During the program year Brazil was added to the countries in which RFF work is located, and work continued actively in Mexico and Argentina. In Chile our association with the Latin American Institute for Economic and Social Planning (ILPES) continues, enabling RFF to study problems not only in that country but in others, particularly Bolivia, Peru, and Venezuela.

During the year RFF made a grant of $10,800 to the University of Minnesota in support of a project conducted by Hans Gregersen, assistant professor at the University's College of Forestry. Gregersen is studying the structure of foreign investment in forest product industries in Latin America, the relationships between the investors and the host countries, and the impact of the investments on the country. This study of a renewable resource industry should provide useful points of comparison and contrast with Raymond F. Mikesell's *Foreign Investment in the Petroleum and Mineral Industries*, which is referred to in more detail in the energy and minerals section of this report.

A significant body of RFF research on the relationship between resources and development in Latin America already has been published, some of it in Spanish. During the year Pierre Crosson's book, *Agricultural Development and Productivity: Lessons from the Chilean Experience*, was published, and a Spanish language

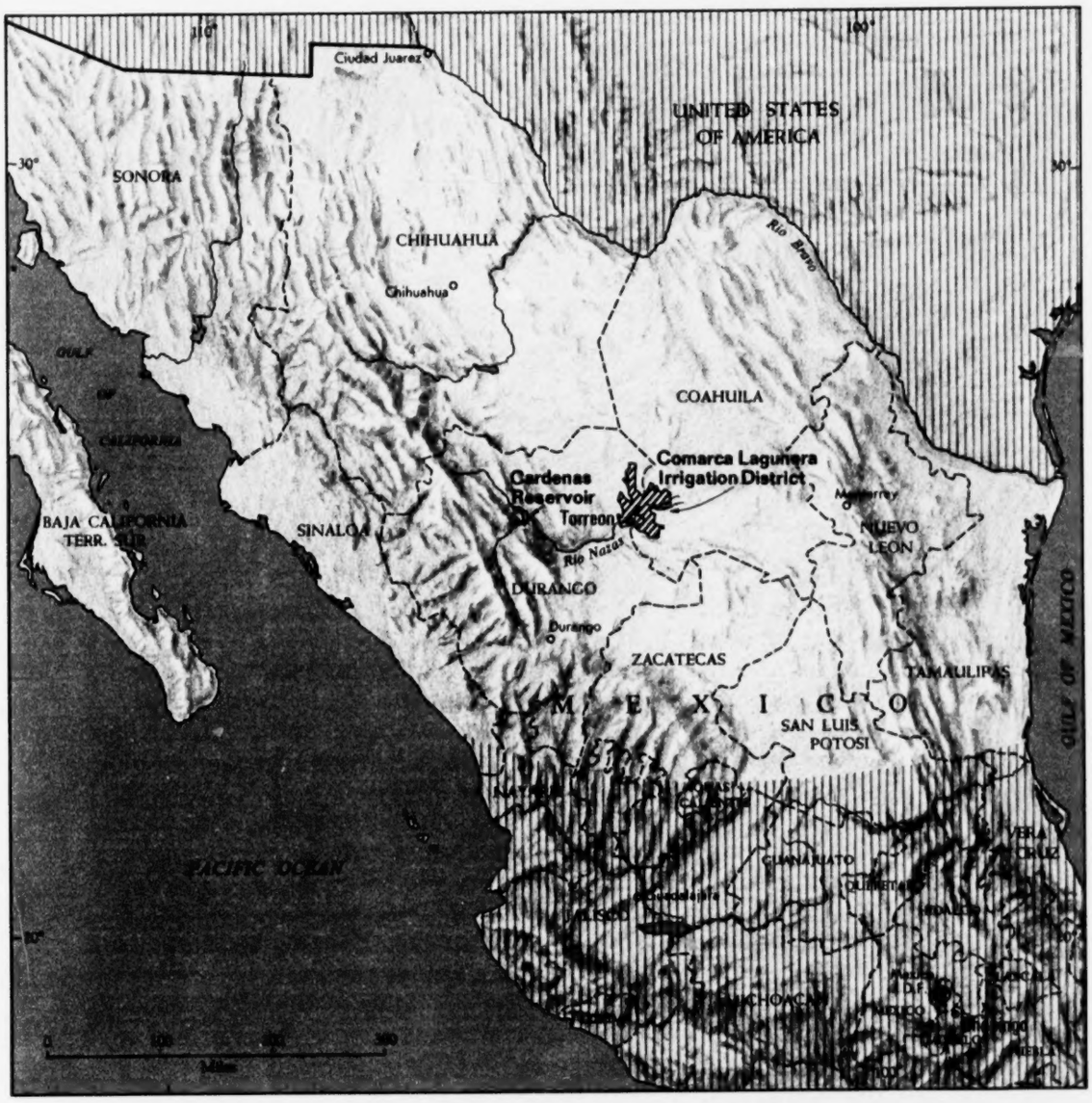
version of Orris Herfindahl's book, *Natural Resource Information for Economic Development* (a joint RFF-ILPES study) was published under the title *Los Recursos Naturales en el Desarrollo Económico.* A monograph by Ronald Cummings was completed during the year and is being prepared for publication in 1972. It also will be published in Spanish. It deals with reservoir and irrigation district management in a major agricultural region of northern Mexico. In this area water receipts are small relative to the amount of irrigable land, supplies are subject to great variation from year to year, and evaporation losses are high. The study analyzes the optimum pattern of release from the Cardenas reservoir and the appropriate pattern and location of production. As a by-product of this and other work on the water resource problems of Mexico, Cummings prepared a paper on the management of underground water for publication in the December 1971 issue of *Water Resources Research.*

Mexico

A highlight of the program in Mexico, where Ronald Cummings is RFF's representative, was the establishment of a Water Management Program in the Center for Agricultural Economics at the Postgraduate College of the National Agricultural School in Chapingo. This program, conceived by Cummings and established under his leadership, is designed to further research and teaching on the development and management of Mexico's water resources. It has received financial support from the Mexican Ministry of Water Resources (SRH) and has the full backing of the host college.

The major research effort of the Water Management Program so far has been a study of a project that would transfer surplus water 300 miles up the northwest coast of Mexico to supplement declining groundwater supplies in a prospering agricultural region in the state of Sonora. The study, undertaken at the request of SRH, is directed by Cummings, working with two senior staff members and three graduate students of the Center. Their principal objective is to determine the net economic return of water in the area of destination, taking into account other water uses that might be made along the way. A novel feature of the analysis is that it explicitly incorporates the indirect impact of the project on urban development in the region by way of an agricultural multiplier, measuring the extent to which other activities in the area will be generated by an increase in agricultural production.

RFF joined with the Center for Agricultural Economics and SRH to sponsor a conference on planning for water development, held in Mexico City in June. The conference was organized by RFF, whose board chairman, Erwin D. Canham, delivered the opening address. Major papers were presented by Steven Marglin of Harvard University and Charles W. Howe of the University of Colo-



More than half of Mexico's arable lands lie in the arid North. There, the established irrigation districts rely for their water mainly on a reservoir located in distant mountains to capture runoff. The relatively small supplies stored in the reservoir are subject to high evaporation losses ranging annually from 9-15 percent of storage. A great deal of water is also lost through filtration and evaporation in transit from reservoir to district and in distribution to farmlands via noncompacted dirt canals and laterals. Losses of this type range from 30 percent of delivered water in one irrigation district to 70 percent in another. At the farm level, water is allocated by quotas. Thus, water management—for the reservoir, the transmission system, and the farmlands—becomes the key determinant of the farmer's welfare. (See Cummings's study mentioned on page 86.)

rado and formerly of RFF. Later, Marglin and Howe met with key personnel of the Water Resources Ministry and the Office of the President for a series of seminars.

In July Howe was invited by the conference sponsors to return to Mexico for further consultations with SRH and the Center. While there he also joined with Cummings in the study of the water transfer project mentioned above.

Pierre Crosson spent the summer in Mexico working with two graduate students from Chapingo on a study of the urbanization process in Mexico. This project is designed to complement Cumming's work; Crosson will estimate the impact of the project on urban development. Crosson also is working with Luis Unikel, professor at the Colegio de México, in supervising case studies of the relationship between agricultural development and urbanization in two other areas of Mexico. RFF is providing financial support and guidance to the students at the Colegio who are doing the studies as master's theses.

Argentina

Delbert Fitchett completed his term as RFF representative in Argentina in mid-year and is now with the staff in Washington finishing the research he began in Argentina into the resource-based economic potential of the Comahue area of northern Patagonia. Focusing principally on agriculture, he has analyzed the potential expansion of irrigated acreage and the evolution of crop patterns in the light of opportunities elsewhere in the country and markets for the products. An early version of his work was read at the meeting of the Argentine Agricultural Economics Association in July 1971. Related studies of the mineral and tourism industries of the Comahue area are being conducted by the Di Tella Institute under RFF sponsorship. These, together with Fitchett's work, should produce a thorough treatment of expansion possibilities in a region where the Argentine government long has aspired to accelerate development. Early in the year Fitchett delivered a series of lectures on river basin planning at La Plata University.

Kenneth Frederick, who became RFF's representative in Argentina in July, will be working out of the city of Mendoza, a thriving center of irrigated agriculture and Argentina's principal grape and wine region. He expects to collaborate in the work of the Instituto Nacional de Economía Legislación y Administración del Agua (INELA), an autonomous institute of the Argentine government established for training and research in the field of water administration. Additionally, he expects to work with students and faculty at Cuyo University in Mendoza. Frederick was recently with the California Institute of Technology and has had previous experience in Latin America with the U.S. Agency for International Development.

Brazil

In August Arthur Silvers, on leave from Rutgers University, started a two-year term as RFF's representative in Brazil. The Brazilian institution with which RFF is associated is the Center of Regional Development and Planning (CEDEPLAR), a part of the University of Minas Gerais in Belo Horizonte. CEDEPLAR is both an undergraduate and graduate center for training and research in this field and ranks among the best in Brazil for the quality of its staff and students. In view of the size and diversity of the country and its strong tradition of decentralization, effective planning in Brazil must rest on better understanding of regional economies and on better coordination of regional and national plans. Silvers, who is a specialist in urban and regional planning, is examining the economy of Belo Horizonte as a member of a team of Brazilian specialists. Thereafter he intends to study Brazilian state planning methods and how state planning can be brought into closer contact with the federal planning apparatus. He will conduct a seminar for staff members of the Center; later he will work within the Center's teaching program.

Work with ILPES

Michael Nelson continues as RFF's representative in the joint research program with ILPES in Santiago, Chile. Nelson, whose study of tropical land settlement in several Latin American countries is under review, has turned his attention to an evaluation of the relative merits of two strategies for coping with the problem of rural underemployment and agricultural stagnation — new land developments and more intensive use of cultivated land. His study will focus on the advantages of intensive versus extensive land use in Peru's three major agricultural zones: the coast, the mountainous interior, and the eastern jungle. Roy Lave, with the Industrial Engineering Department at Stanford University, is collaborating on some aspects of the study.

In addition to his research Nelson served during the year as agricultural advisor with ILPES planning missions to Venezuela and Bolivia, and was consultant to the Agency for International Development on agricultural programs in Peru. While there he participated in a series of seminars held by the Peruvian Ministry of Agriculture.

Publications

Most of the research done by Resources for the Future takes final shape in the form of books, journal articles, and reprints meant for a readership concerned with natural resources and the quality of the environment, including academic specialists, general students, citizens' groups, and administrators in business, industry, and government.

BOOKS. During the 1970–71 program year, seventeen new books were published and eight others were sent to press; these titles are indicated by an asterisk in the full list of publications below.

Book-length studies published by or for RFF fall into two categories: (1) hardcover books for individual or library use, some of which are also made available as low-priced paperbacks for use as texts or supplementary readings in colleges and universities; and (2) paperbound monographs on more specialized research, reconnaissance studies, and collections of papers presented at conferences sponsored by RFF. Most of the books in the first category are published and distributed for Resources for the Future by The Johns Hopkins Press and are indicated in the list below as JHP; the few issued through other publishers are so identified. Books in the second category, which are published by Resources for the Future, are distributed by The Johns Hopkins Press. They are identified in the list as RFF.

GRANT-SUPPORTED STUDIES published by other institutions. Books based on research supported or partially supported by RFF grants and issued by other publishers during the last five years are listed on pages 95 and 96.

THE RFF REPRINT SERIES. This series makes available selected papers written by RFF staff members and originally published in journals or proceedings. Single copies are free on request. Six new reprints were added during the program year. Reprints available at the close of the year and staff writings published in professional journals during the year are listed on pages 97 and 104–6.

RESOURCES. This bulletin, issued three times a year, contains brief articles based on material from recent RFF books or papers. The January issue reviews some significant events of the previous year relating to the use and management of natural resources. The bulletin, which varies in length from four to sixteen pages, is free on request.

BOOKLETS. The following are available free: a brief description of the organization, *Resources for the Future, Inc.: Its Aims and Work;* a booklet listing RFF fellowship recipients from 1960 to 1967, together with their past and current affiliations; and a list of RFF books in print. Also available is a report on the work of the Committee on Urban Economics and of development in the field from 1959 to 1968, entitled *Progress in Urban Economics.* Single copies of this 142-page publication are available free; additional copies are $1.00 each.

RFF BOOKS STILL IN PRINT

NATURAL RESOURCES AND ECONOMIC DEVELOPMENT

Arrow, Kenneth J., and Mordecai Kurz. *Public Investment, the Rate of Return, and Optimal Fiscal Policy.* JHP, 1970; second printing 1971. 248 pp. $9.00.

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97. *Option Demand and Consumer Surplus: Further Comment*, by Charles J. Cicchetti and A. Myrick Freeman III. From *Quarterly Journal of Economics*, vol. 85 (August 1971).
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***Reprints listed are available from RFF; single copies free on request; additional copies of the same reprint at 25 cents each, except No. 10 and No. 85 (50 cents).**

Related Staff Activities and Writings

ACTIVITIES — A SELECTIVE LIST

BLAIR T. BOWER. Consultant to the New York State Office of Planning Coordination; Maryland Environmental Service; and Office of Solid Wastes, Environmental Protection Agency. Served on editorial boards of the *Natural Resource Journal* and the *Journal of Soil and Water Conservation*. Faculty member, Curso Sobre el Control de la Contaminación del Agua, PAHO, and Universidad Nacional Autónoma de México, Mexico City; and visiting lecturer, Department of City and Regional Planning, University of North Carolina. Member of the Visiting Committee, Environmental Systems Management Program, School of Architecture and Urban Planning, University of California at Los Angeles. Panelist at Jeffries and Company Conference on Background for Investment Decisions, Hawaii; and member of Panel on Forecasting, National Water Commission. Participated in and gave a paper at the Conference on Environmental Management of an Urban World System, Netherlands University Foundation for International Cooperation, Noordwijk. Spoke on various aspects of environmental quality management at Triangle Universities Consortium on Air Pollution Workshop, Southern Economics Association session on air quality management, and at meetings of Corps of Engineers planners, and the Harvard University Environmental Systems Group.

MICHAEL F. BREWER. Served on Advisory Committee to Environmental Program, Oak Ridge National Laboratory. Chaired panel on New Economic Roles for the Rural Environment at American Agricultural Economics Association winter meeting, Detroit. Presented the following papers: "Delineating Targets for Natural Resources Research," at the Annual Meeting of Committee on Economics of Natural Resources Development, San Francisco; "Should Economics Dictate Resource Allocation Decisions?" at 36th North American Wildlife and Natural Resources Conference, Portland, Oregon; "Environmental Pressures on Population Growth" at U.S. Department of State Conference on Population, Airlie House, Virginia; "Agri-Systems and Eco-Cultures, or: Can Agriculture Internalize its Environmental Externalities?" AAEA National Conference on Agriculture's Effect on Environmental Quality, Southern Illinois University, Carbondale. Gave keynote address, "Breakdowns in Society's Metabolism," at Symposium on Environmental Quality and Social Responsibility at Green Bay, Wisconsin; spoke on regional research in the area of environmental quality at a Southern Land Economic Research Committee meeting at Biloxi, Mississippi; and lectured on "Environmental Concerns of Agricultural Economics" at University of Missouri-Columbia.

FRANCIS T. CHRISTY, JR. Served as member of the Executive Committee, Law of the Sea Institute; Law of the Sea Panel, American Society of International Law; Commission to Study the Organization of Peace; International Marine Science Affairs Policy Committee, Ocean Affairs Board, National Academy of Sciences; Advisory Council, Ocean Studies Program, Woodrow Wilson International Center for Scholars; Advisory Panel for Sea Grant Projects, National Oceanic and Atmospheric Agency; and Economic Potential Committee,

Marine Technology Society. Participated in Conference on Fishery Economics held by National Marine Fisheries Service, U.S. Department of Commerce; and FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fisheries, Rome. Advised on planning ocean resources sessions of the 4th Annual Joint Meeting of Producers and Users of Operations Research, Gaithersburg, Md. Spoke on Issues on the Law of the Sea to the Darien (Conn.) Community Association. Presented paper, "Implications for Fisheries of the U.S. Draft Convention on the Sea-Bed," to the Marine Technology Society Symposium, The Law of the Sea: A Year of Crisis. Prepared paper, "Suggestions for Studies of Fishery Problems," for a meeting of the Ad Hoc Working Group on International Fishery Regulations, Ocean Affairs Board, National Academy of Sciences, Seattle. Spoke to 33rd Annual Meeting of the Pacific Fishery Biologists on ownership of ocean resources, Gearhart, Oregon, and presented paper on that subject at the annual convention of the Izaak Walton League, Anaheim, California. Participated in planning program; chaired session; and gave paper, "Research Needs on Ocean Issues," at 6th Annual Conference of the Law of the Sea Institute, University of Rhode Island. Led seminar on "Role of the Federal Government in Development of Marine Resources," at Marine Minerals Technology Center, U.S. Department of Commerce, Tiburon, Calif.

CHARLES J. CICCHETTI. Adviser to the Subcommittee on Outdoor Recreation, Northeast Regional Resources Research Committee. Associate editor of the *Journal of Leisure Research*. Testified at the U.S. Department of the Interior Hearings on the Proposed Trans-Alaska Pipeline. Presented seminars on issues of preservation versus development at the University of Wisconsin and the State University of New York at Stony Brook. Served as reviewer for research proposals submitted to the National Science Foundation and as a member of their site visit team for the Lake Tahoe Research Project. Served as panelist at the 15th World Congress of the International Union of Forestry Research Organizations. With John V. Krutilla, presented a paper, "Preservation versus Development: Some Economic Issues," at the December 1970 meeting of the Econometric Society.

MARION CLAWSON. Served as director of the National Conference on State Parks, on the Program Committee for its 1971 meeting, and as chairman of its Committee on Budget and Finance. Member of the Advisory Committee on Flood Insurance, Department of Housing and Urban Development. Named as member of the President's Advisory Panel on Timber and the Environment. Presented a paper on the international aspects of the environmental impact of economic development at the Symposium on Political Economy of the Environment in Paris; and another on urbanization and the modernization of agriculture at the International Conference on Urbanization and Development in Rehovot, Israel. At a conference on the management of federal lands, sponsored by the University of California at San Francisco, gave a paper, "Economic Aspects of Public Lands," and participated in a review of the report by the Public Land Law Review Commission. Presented a paper, "Alternative Land Use Patterns and Environmental Quality," to the Northeast Agricultural Economics Council in Amherst, Mass. At the University of Guelph in Canada, led a seminar and lectured on resources, economic development, and environmental quality. Led seminars before the agricultural economics staffs of the University of California at Davis and of the University of Wisconsin. Participated in the annual conference of the Society for International Development in Ottawa. Met with the Subcommittee on Resource Allocation of the Agricultural Board of the National Academy of Sciences in Chicago to consider agricultural development and environmental quality. Spoke on resource economics to the Natural Resources Committee of the U.S. Chamber of Commerce, and one on the economics of outdoor recreation to the Ontario Society of Professional Foresters in Toronto. In Chicago, at a symposium sponsored by the Committee on Arid Lands of the American Association for the Advancement of Science, spoke on urbanization in the arid lands. Gave talks on long-run problems of rural adjustment, Montana State University; on resource adjustment and quality of the environment problems, Rio Grande Chapter of the Sierra Club, Santa Fe; on economic and social aspects of pollution control, National Council for Social Studies, New York City; and on economic and social aspects of natural resource use, Natural Resources Roundtable, Washington, D.C. Met with several semi-

nar groups and gave talks on various subjects at Oklahoma State University. Under the auspices of the U.S. Department of Agriculture Graduate School, spoke to agricultural groups on rural-urban balance and the problems of nonmetropolitan areas.

PIERRE R. CROSSON. Conducted a seminar at El Colegio de México, Mexico City, on current research on urbanization in Mexico; and during the summer of 1971 was visiting professor, Center for Agricultural Economics, Chapingo, Mexico, and visiting researcher, El Colegio de México.

JOEL DARMSTADTER. Participated in the World Energy Conference in Bucharest. Spoke on current energy problems before The Economic Panel, a group of corporation executives, in New York City. Panelist at the session on resources, Urban Technology Conference, American Institute of Aeronautics and Astronautics, New York City. With Sam Schurr, presented a paper, "Energy Resources Relative to Energy Needs in the Light of Emergent Economic and Social Issues," before the American Nuclear Society in Boston.

JEROME K. DELSON. As a consultant to the UN Department of Economic and Social Affairs, prepared a background paper, "Energy and Environmental Policy for Developing Countries," for the 1972 UN Conference on Human Environment to be held in Stockholm.

EDGAR S. DUNN, JR. Member of the Advisory Board for the Project on Computer Data Banks, National Academy of Sciences; and of the Executive Committee, Southern Economics Association.

JOSEPH L. FISHER. Member of the Ocean Affairs Board, National Science Foundation; and of the Commission on Education and the Committee on Public Engineering Policy, both of the National Academy of Engineering. Also served on the Committee of Consultants for the forthcoming UN Conference on the Human Environment; and the Committee for Arctic Development, Arctic Institute of America. Delivered the Horace Albright Lecture, entitled "Conservation as Research, Policy, and Action," at the University of California at Berkeley; and was University Regents Lecturer at the University of California in Santa Cruz. As guest speaker at the Senior Seminar in Foreign Policy of the Foreign Service Institute, Department of State, spoke on resource trends, issues, and prospects. Delivered three papers: "Elements in a National Energy Policy," at the Western Resources Conference held in Golden, Colo., at the Colorado School of Mines; "Impact of Population on Resources and the Environment," at the annual meeting of the American Economics Association in Detroit; and "Natural Resource Policies for the Future," at a Brookings Institution seminar on U.S. government operations and policy issues. Gave a talk, "Urban Man — At Home or Adrift?" to the City Club of Portland, Ore.

MASON GAFFNEY. Gave a paper, "Is the Property Tax Regressive?" at the 64th Annual Meeting of the National Tax Association, Kansas City. Advised Montgomery County (Md.) Council on construction of cadastral surveys and led a discussion on the use of such surveys at a meeting of the City Council and Wisconsin Property Owners' League, Beloit. Lectured on replacement demand and full employment at the University of Pittsburgh; on land values and inflation and on city planning and the property tax at two meetings of the Commonwealth Club of California; and on reconciling full employment and environmental quality at Clemson University. Delivered a paper, "World Resources and Neo-mercantilism," at the 10th Annual Meeting, Committee on Taxation, Resources, and Economic Development, University of Wisconsin. Gave a seminar on policies for urban renewal and revival, Klutznick Corporation Planning Group, Chicago; and gave the 1970 Vinton Lecture, "How to Recover from Urban Sprawl," at Montgomery College, Rockville, Md. Led a seminar on tax assessment of natural resources, Joint Ways and Means Committee, Montana State Legislature, Helena; and one on forest taxation, Trees for People Program, Washington, D.C. Chaired a session at the University of Wisconsin Conference on Water Quality, Milwaukee. Gave an address on the valuation of mineral deposits at the annual convention of the Assessors' Association of West Virginia, sponsored by the West Virginia State Tax Commission. Conducted a seminar on capital theory at The Johns Hopkins University.

EDWIN T. HAEFELE. Chairman of the Advisory Panel on U.S. Strategy for Developing Nuclear Merchant Ships, Maritime Transportation Research Board, National Academy of Sciences. Member of the Committee on Social, Economic, and Environmental Factors of Transportation, Highway Research Board, National Academy of Sciences; the review panel for *Multistate Regionalism in the Federal System*, Advisory Commission on Intergovernmental Relations; and the Governing Council, College of Logistics, Institute of Management Sciences. Lectured on technical assessment and social choice mechanisms at Oak Ridge National Laboratory and spoke on intangible and non-ocean elements of the negotiation process as a panel member at the 6th Annual Conference of the Law of the Sea Institute, University of Rhode Island. Presented a paper on social choices and individual preferences at the Seminar on Economics and Decision Making for Environmental Quality, University of Florida. Other papers included: "Executive Government: Our Present Confusion," Washington Operations Research Council; "The Feasibility of Facility User Charges in Northern Transport," Conference on Arctic Transportation, Yellowknife, Northwest Territories, Canada; and "Social Choice in Residual Management: Politicizing an Economic Model," American Political Science Convention, Chicago.

ORRIS C. HERFINDAHL. Served on the Panel on Scientific and Technical Information for Developing Nations of the National Academy of Sciences. Participated in the American Geological Institute Conference on Conservation and the Minerals Industry — A Public Dilemma, at Hot Springs, Va. Lectured on social benefits and costs and the materials outlook, at the University of Wyoming; and on problems of environmental quality during the series, "Science and Technology in Foreign Affairs," sponsored by the Foreign Service Institute. Presented the opening paper, entitled "Quality of the Environment — an Overview," at the meeting of the Council on Higher Education in the American Republics in Santa Maria, Peru. Gave two other papers: "Defining the Problem of Environmental Quality," at the Centennial Conference on Quality of the Environment at Ohio State University; and "What Are the Economic Considerations in Assessing the Role of Remote Sensing in Country Development?," at the U.S. Agency for International Development Symposium on Utility of Remote Sensing as an Aid to Developing Countries, at the Smithsonian Institution.

IRVING HOCH. Member of the Committee on Taxation, Finance, and Pricing of the Highway Research Board, National Academy of Sciences. Associate of the Committee on International Exchange of Persons (Senior Fulbright-Hays Program) and member of its Advisory Committee for Western Europe and several of its review panels. Lectured on vertical transportation (elevators, escalators) to a class in urban development at The George Washington University. Participated as member of ad hoc committee in Highway Research Board conference on community flow in urban areas.

ALLEN V. KNEESE. Participated in the meeting of the Economic Commission for Europe, held in Prague in May, serving as a consultant in the preparatory stage and presenting a paper, "The Benefit-Cost Analysis of Environmental Pollution," at the meeting itself. Lectured on economic aspects of controlling the environment and on various environmental issues at the University of Illinois, Champaign; at Princeton University; at a seminar organized by the Department of Agricultural Resource Economics, the University of Maine; at a seminar of the Department of Economics, Brown University; and at a meeting organized by the Department of Economics, Indiana University. Presented "Pollution and the Profit Motive" at the 18th Annual Conference of the Joint Engineering Management Conference in Chicago, and spoke on a pricing system to control pollution at the 40th Annual Conference of the Southern Economics Association in Atlanta. Was discussant of Albert Breton's paper, "The Non-internalization of Externalities," at the joint session of the Association for Comparative Economics and the Association for the Study of Soviet-type Economics at the annual meeting of the American Economics Association. Chaired a session of the 5th International Conference on Input-Output Techniques, in Geneva, sponsored by the United Nations and Harvard University. At the request of three prominent economists from Japan, organized and chaired a staff workshop on environmental problems. Presented

"The Economics of Environmental Pollution in the United States" at a Conference on Goals and Strategy for Environmental Quality Improvement in the Seventies, sponsored by the Atlantic Council of the United States and Battelle Memorial Institute. Served as a member of the Panel on International Law and the Global Environment, sponsored by the American Society of International Law, in Washington. Presented "The Ruhr, the Delaware, United States, and Water Quality Management," at the Environmental Resources Seminar of the Department of Civil Engineering, University of Delaware; and lectured on water quality in rivers and reservoirs at a water quality training course of the Corps of Engineers, in Cincinnati. Conducted a discussion on barriers to industrial pollution control at The Brookings Institution's Round Table for Corporate Executives. Participated in the annual meeting of the National Academy of Sciences–National Research Council, Washington. Presented a paper, "Incentives and Environmental Management," at the 18th Ontario Industrial Waste Conference sponsored by the Ontario Water Resources Commission, at Niagara Falls. Was an advisor for the first meeting of the Subcommittee on Improving the Quality of the Environment of the Committee for Economic Development, in New York; and chaired a session on taxation and management of environmental quality at the national Tax Association Annual Conference in Kansas City. As a Royer visiting professor of political economy, at the University of California, Berkeley, gave two lectures on water quality management, one on what has been learned from economic research and the other on the present national water pollution control program and a possible alternative. Served as a member of the Committee Advisory to the National Oceanic and Atmospheric Administration (formerly Environmental Science Services Administration) of the National Academy of Sciences, and was chairman of the Subcommittee on Model Environmental Systems Analysis.

JOHN V. KRUTILLA. Continued service on the Committee on Support of Dissertation Research on Recreation and Leisure of the National Academy of Sciences; the National Air Quality Criteria Advisory Committee of the Environmental Protection Agency; and the Senior Technical Advisory Panel of the UN Development Program–Vistula River Project. Consultant to the Department of Recreation and Conservation of the Province of British Columbia; and for the Forest Service Sawtooth–Boulder–White Clouds –Pioneer Mountains region study. At the University of Idaho, presented an evaluation of the benefits of preserving Hells Canyon as a natural area. Lectured at the University of Guelph in Canada and conducted a seminar at The Johns Hopkins University on including the value of science resources in benefit-cost analysis. Conducted a seminar at the University of Michigan on the question of the carrying capacity of low-density resource-based recreational areas. In Detroit, presented a paper at the annual meeting of the American Statistical Association and, with Charles Cicchetti, gave another at the annual meeting of the Econometric Society.

HANS H. LANDSBERG. As a member of the Panel of Experts for the UN Conference on the Human Environment (Stockholm, 1972), participated in a Development and Environment session in Geneva, helped to draft the so-called *Founex Report,* and continued to serve the secretariat in an informal advisory capacity. Participated in the 13th Pugwash Symposium, whose theme was "Social Aspects of Technological Change," in Frascati, Italy; and in the Joint Colloquim on International Environmental Science before the Senate Committee on Commerce and the House Committee on Science and Astronautics. Continued as a member of the Load-Forecasting Methodology Advisory Committee of the *1970 National Power Survey* being prepared by the Federal Power Commission. At the National Academy of Sciences, served on the Committee for International Environmental Programs and chaired a two-day workshop on environment and development; served on the National Materials Advisory Board–Committee on Technical Aspects of Critical and Strategic Materials; and on the Committee on the Survey of Materials Science and Engineering, its Executive Board, and its Panel on the Nature of Materials Science and Engineering. Spoke on international environmental problems at the Columbia University workshop on "Economic Development versus Environmental Protection" sponsored by the School of International Affairs and Salk Foundation.

GEORGE O. G. LÖF. Served as consultant to World Health Organization on water quality improvement in Poland, and to the Illinois State Water Survey's workshop and panel on heat discharges into environment, sponsored by National Science Foundation. As professor of civil engineering, taught courses in water quality at Colorado State University. Lectured on developments in solar energy for NASA lecture series at Goddard Space Flight Center. Served on two National Academy of Sciences committees: Technologies and Water, and Utilization of Solar Energy in Developing Nations. Presented paper, "Economics of House Heating with Solar Energy," at meeting of International Solar Energy Society.

THOMAS H. E. QUIMBY. Lectured on solid waste management to engineering and natural resources management classes at the University of Michigan. Presented a paper, "What New Incentives Are Needed?" (for waste recycling) at the 1st National Conference on Composting-Waste Recycling in Denver; and another, "Recycling is Fashionable," to the Baltimore-Washington Underwriting Club in Washington, D.C. Spoke on the place of recycling in solid waste management before the National Capital Section of the American Water Resources Association in Washington, D.C.

RONALD G. RIDKER. Consulted with the government of Malaysia on a proposed experiment with monetary incentives for family planning. Gave a talk, "Unemployment in Developing Countries: Comparisons of South Asian and Southeast Asian Experience," at the Conference on Employment and Unemployment in Southeast Asia, held in Singapore; and another, "Methodology Used in Project on Estimation of Resource and Environmental Consequences of Population Growth in the United States," at the Conference on Environmental Model Building, sponsored by the University of California at Riverside. Presented two papers: "Population and Pollution," at the annual meeting of the Population Association in Washington, D.C.; and "Some Economic Implications of ZPG," at a meeting of the National Industrial Conference Board in New York City. Participated in a seminar, "Unemployment in the LDC's," sponsored by the Overseas Development Council in Washington, D.C.; and at the Council's Development Issues Seminar, commented on a paper by Lester Brown. Participated in the Conference on the Use of Monetary Incentives for Population Control at Chapel Hill, N.C.; the Conference on Non-Renewable Resources, sponsored by the Division of Earth Sciences, National Academy of Sciences; and a meeting of the Southern Economics Association in Atlanta.

CLIFFORD S. RUSSELL. Conducted seminars on environmental quality and regional modelling work at the Woodrow Wilson International Center for Scholars, Smithsonian Institution; University of Wisconsin; University of Connecticut; National Bureau of Standards; and the NASA-ASEE Engineering Systems Design Program, Langley Air Force Base, Hampton, Va. Presented a paper, "Regional Environmental Quality Management: A Quantitative Approach," at the California Institute of Technology Conference on Technological Change and the Human Environment, in Pasadena.

SAM H. SCHURR. Continued as 1970 Henry Krumb Lecturer of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), and spoke on "Prospects for Change in the International Oil Industry" at sectional meetings in Grand Junction and in Houston. Served as member of the Economics Committee of the American Chemical Society in their study of chemistry and the U.S. economy, and as a member of the steering group of the Committee on Power Plant Siting (COPPS) of the National Academy of Engineering. Conducted a seminar on U.S. energy policies and problems at the Lyndon B. Johnson School of Public Affairs in Austin. Delivered a lecture on "Middle Eastern Oil in the Next Decade: Some Uncertainties" to the Petroleum Exploration Society of New York and a paper on "Some Elements in the Political Economy of Middle Eastern Oil" at Louisiana State University in New Orleans. With Joel Darmstadter, prepared a paper on "Energy Resources Relative to Energy Needs in the Light of Emergent Economic and Social Issues" for presentation at the annual meetings of the American Nuclear Society in Boston.

V. KERRY SMITH. Presented papers "Nonlinear Estimation Incorporating Prior Identifying Information versus Ordinary Least Squares," to the American Institute for Decision Sciences,

Dallas; and "Simulation and Spectral Analysis of a Model of a Developing Economy," to the Summer Computer Simulation Conference, Boston. Was co-author of the following papers: "A Time-Series Analysis of Interest Rates in the United States" and "A Generalization of Theil's k-Class of Estimators under Degrees of Freedom Constraints," presented to the American Statistical Association, Detroit; and "An Examination of Liquidity, Income, and Price Expectations Effects upon Interest Rates," presented to the Western Economics Association, Vancouver, B.C.

WALTER O. SPOFFORD, JR. Served on the steering committee of the 1st National Conference on Composting — Waste Recycling, Denver, and on the organizing committee of the Engineering Foundation Research Conference on Engineering and Social Costs in Environmental Control, Deerfield, Massachusetts. Presented "Solid Waste — The Junk We Discard" to 11th Carnegie Conference, Carnegie-Mellon University, Pittsburgh, and "Some Economic Considerations in Reclaiming Fiber" to the Conference on Fiber Recovery from Solid Waste and Its Use, Miami University Pulp and Paper Foundation, Oxford, Ohio. Served as a panel member for Recycling Day in New York; and as moderator of the sessions on materials recovery and reuse, and ultimate disposal of residuals, at the Engineering Foundation Research Conference on Engineering and Social Costs in Environmental Control, Deerfield, Mass.

LOWDON WINGO. Consultant on urbanization in developing countries to the International Bank on Reconstruction and Development. Served on the Panel on Costs of Urbanization of the Organisation for Economic Co-operation and Development in Paris. Member of the Evaluation Panel of the Appalachian Regional Commission; the Urban Management Panel of the President's Advisory Commission on Management Improvement; the Executive Committee of the Committee on Urban Economics; the Committee on Urban Public Economics; and the U.S. Editorial Board of the journal *Urban Studies*, sponsored by the University of Glasgow. Prepared a paper, "National Development Objectives and Metropolitan Concentration," for the Conference on Urbanization and Development in Developing Countries, held in Rehovot, Israel. Lectured on economic aspects of new communities at the Symposium on New Communities at the Reston Center of Virginia Polytechnic Institute; and on economic issues in national urban growth policy at the Yale University Seminar on Policy Issues in Urban Studies.

WRITINGS — A SELECTIVE LIST

Bower, Blair T. "Residuals and Environmental Management." *Journal of the American Institute of Planners*, vol. 37, no. 4, 1971, pp. 218-20.

———, with C. W. Howe. "Policies for Efficient Regional Water Management." *Proceedings, American Society of Civil Engineers*, vol. 96, no. IR 4, 1970, pp. 387-93.

———, with W. R. D. Sewell. "Selecting Strategies for Air Quality Management." Resource Paper No. 1. Ottawa, Canada: Department of Energy, Mines, and Resources, Policy Research and Coordination Branch, 1971.

———, with Walter O. Spofford, Jr. "Environmental Quality Management." *Natural Resources Journal*, vol. 10, no. 4, 1970, pp. 655-67.

Christy, Francis T., Jr. "Economic Problems and Prospects for Exploitation of the Resources of the Sea-Bed and Its Subsoil." In *Symposium on the Exploration and Exploitation of the Sea-Bed and Its Subsoil.* Strasbourg, France: Council of Europe, 1971.

———. Preface to Ann L. Hollick, *Marine Policy, Law and Economics: Annotated Bibliography*. University of Rhode Island: Law of the Sea Institute, 1970.

Cicchetti, Charles J. "Some Economic Issues Involved in Planning Urban Recreation Facilities." *Land Economics*, Winter 1970.

———, with A. Myrick Freeman III. "Consumer Surplus and Option Value in the Estimation of Benefits." *Quarterly Journal of Economics*, vol. 85, August 1971.

———, with A. Myrick Freeman III, Robert H. Haveman, and Jack L. Knetsch. "On the Economics of Mass Demonstrations." *American Economic Review*, vol. 61, no. 4, September 1971.

———, with J. J. Seneca. "User Response in

Outdoor Recreation: A Reply." *Journal of Leisure Research*, Spring 1970.
Clawson, Marion. "Agriculture in an Advanced Economy." In *Rural Development in a Changing World*, edited by Raanan Weitz. Cambridge: MIT Press, 1971.
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———. "Conflicting Pressures on Forest-Resource Managers and the Role of the Public in Management Decisions." *Proceedings of the Annual Meeting*, Allegheny Section, Society of American Foresters, White Sulphur Springs, W. Va., February 1971.
———. "Economic Considerations in Arid Land Use." In *Public Land Policy*, edited by Phillip A. Foss. Proceedings of the Western Resources Conference, Fort Collins, Colorado, 1968. Boulder: Associated University Press, 1970.
———. "Land Resources." In *Environment: Resources, Pollution, and Society*, edited by William W. Murdoch. Stamford, Conn.: Sinauer Associates, 1971.
———. "More and Better, But How? A Recap of Our Natural Resource Choices." In *Contours of Change, Yearbook of Agriculture, 1970*, U.S. Department of Agriculture. Washington, D.C.: Government Printing Office, October 1970.
———. "Population, Settlement, and Growth Patterns." *American Journal of Agricultural Economics*, December 1970.
———. *Resources, Economic Development, and Environmental Quality*. Publication No. 42, Centre for Resources Development, University of Guelph, Canada: September 1971.
———. "Resources and Technology for Balanced Growth." In *Toward Policies for Balanced Growth*, edited by Donald L. Nelson. Washington, D.C.: USDA Graduate School Press, 1971.
———. "State Parks and Recreation Areas Are Vital." *Parks and Recreation*, December 1970.
———. "Urban Research Needs a Boost." *Nation's Cities*, October 1970.
Dunn, Edgar S., Jr. "A Flow Network Image of Urban Structures." *Urban Studies*, vol. 7, no. 3, October 1970.
———. "Distinguishing Statistical and Intelligence Systems." In *Information Technology in a Democracy*, edited by Alan F. Westin. Harvard Studies in Technology and Society. Cambridge: Harvard University Press, 1971.
Fisher, Joseph L. "Alaska Oil in Historical Perspective." In *Change in Alaska: People, Petroleum, and Politics*, a compendium of papers presented at the Twentieth Alaska Science Conference held at the University of Alaska in August 1969. College: University of Alaska Press, 1971.
———. "Dimensions of the Environmental Crisis." *Zygon*, vol. 5, no. 4, December 1970. Originally presented as a paper at the Seventeenth Summer Conference on Religion in an Age of Science at Star Island, N.H., July 25-August 1, 1970.
———. "The Economic Consequences of Natural Resource Development in Urban Regions." In *Proceedings of the National Conference on Urban Water Research*. Georgia Institute of Technology, March 1970.
———. "Environmental Pollution and the Future of Man's Earth." *Social Education*, vol. 35, no. 1, January 1971.
———. "An Expanding Future for Soil Conservation." *Journal of Soil and Water Conservation*, vol. 25, no. 6, November-December, 1970.
———. "Impact of Population on Resources and the Environment." *American Economic Review*, vol. 61, no. 2, May 1971.
———. "A Larger Future for Soil Conservation." In *Turning Points in Time: Land, Water, People*, proceedings of the 25th Annual Meeting of the Soil Conservation Society of America. Ankeny, Iowa: Soil Conservation Society of America, 1971.
———. "Policies for Balanced Growth." *Growth and Change*, vol. 2, no. 2, April 1971.
———, with Neal Potter. "The Effects of Population Growth on Resource Adequacy and Quality." In *Rapid Population Growth: Consequences and Policy Implications*. Baltimore: The Johns Hopkins Press for the National Academy of Sciences, 1971.
Gaffney, Mason. "Coordinating Tax Incentives and Public Policy: The Treatment of Land Income." In *Economic Analysis and the Efficiency of Government*. U.S. Congress, Joint Economic Committee, Subcommittee on Efficiency in Government, Part 2, pp. 405-15. Washington, D.C.: U.S. Government Printing Office, 1970.
———. "Federal Water Policy." In *Economic Analysis and the Efficiency of Government*. U.S. Congress, Joint Economic Committee, Subcommittee on Efficiency in Government, Part 2, pp. 334-42. Washington, D.C.: U.S. Government Printing Office, 1970.
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———. "What Is Property Tax Reform?" *Congressional Record*, May 10, 1971, pp. E4152-55.

Haefele, Edwin T. "Decision-Making in Common Property Resources." *Journal of Soil and Water Conservation*, July-August, 1971.

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———. "Environmental Pollution: Economics and Policy." *American Economic Review*, vol. 61, no. 2, May 1971.

———. "Pollution and a Better Environment." In *Symposium on Air Pollution*, edited by Leonard W. Levy. New York: Da Capo Press, 1971.

———. "Strategies for Environmental Management." *Public Policy*, vol. 19, no. 1, Winter 1971.

———, with Robert U. Ayres. "Production, Consumption, and Externalities." In *Is Economics Relevant?*, edited by Robert L. Heilbroner and Arthur M. Ford. Pacific Palisades, Calif.: Goodyear Publishing Company, 1971.

Landsberg, Hans, with Clifford S. Russell. "International Environmental Problems: A Taxonomy." *Science*, June 25, 1971, pp. 1307-14.

Nelson, Michael. *Evaluation of Peruvian Agriculture Relative to U.S. AID Assistance.* Lima, Peru: Ministry of Agriculture and U.S. Agency for International Development, June 1971.

———. *Methodology and Analysis: Bolivian Agricultural Production and Marketing Loan.* La Paz, Bolivia: U.S. Agency for International Development, December 1970.

———. *La Sub-región de Motatan-Cenizo: Bases para un Programa de Preinversión y Desarrollo.* Santiago, Chile: Latin American Institute for Economic and Social Planning, June 1971.

Quimby, Thomas H. E. "What New Incentives Are Needed?" (for waste recycling). *Compost Science*, July-August 1971.

Ridker, Ronald G. "Agricultural Mechanization in South Asia." *Development Digest*, vol. 9, January 1971, pp. 108-13.

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FINANCIAL STATEMENTS

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Price Waterhouse & Co.
1801 K Street, N.W.
Washington, D.C. 20006
26 October 1971

To the Board of Directors of Resources for the Future, Inc.

In our opinion, the accompanying Statement of Assets, Liabilities and Fund Balance, the Statement of Income and Expense, the Statement of Source and Application of Cash, and the Statement of Grants (Exhibits I, II, III and IV) present fairly the assets, liabilities and fund balance of Resources for the Future, Inc., at 30 September 1971 and 30 September 1970, its income and expenses and sources and applications of cash for the years then ended, in conformity with generally accepted accounting principles consistently applied. Our examinations of these statements were made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

Price Waterhouse & Co.

Exhibit I

RESOURCES FOR THE FUTURE, INC.

STATEMENT OF ASSETS, LIABILITIES, AND FUND BALANCE

ASSETS	30 September *1971*	*1970*
Cash	$ 544,390	$ 553,224
Certificates of deposit	800,000	400,000
Grants receivable from the Ford Foundation (Note 1)	4,500,000	6,684,788
Grant receivable from the Rockefeller Foundation (Note 2)	31,485	300,000
Other receivables	106,272	99,843
	$5,982,147	$8,037,855
LIABILITIES AND FUND BALANCE		
Grants payable (Exhibit IV)	$ 228,699	$ 359,355
Accounts payable	85,765	36,389
	314,464	395,744
Fund balance at beginning of period	7,642,111	8,812,271
Less excess of expense over income for the year (Exhibit II)	1,974,428	1,170,160
Fund balance at end of period	5,667,683	7,642,111
	$5,982,147	$8,037,855

Exhibit II

RESOURCES FOR THE FUTURE, INC.

STATEMENT OF INCOME AND EXPENSE

INCOME	*For the Year Ended 30 September*	
	1971	*1970*
Grants:		
Rockefeller Foundation		$ 500,000
General Service Foundation	$ 20,000	
The Ford Foundation	6,917	150,000
Interest	45,681	49,905
Contracts with United States agencies and international agencies	273,925	122,780
	346,523	822,685

EXPENSE	*Staff*	*Grants (Exhibit IV)*		
Program:				
Quality of the environment	$ 444,645	$ 76,636	521,281	444,753
Natural environments	91,022	51,290	142,312	103,675
Land and water	59,921	26,576	86,497	186,985
Energy and minerals	248,141	7,291	255,432	213,452
Regional and urban studies	148,612	4,215	152,327	191,210
Resource appraisals	84,698		84,698	38,118
Special projects	229,816	45,938	275,754	201,111
Latin American	238,878	10,810	249,688	171,371
Publications (less $106,217 received from sales of publications)	236,067		236,067	142,364
	$1,781,800	$222,756	2,004,556	1,693,039
Administration:				
Compensation and employee benefits			188,860	170,002
Travel			12,201	16,178
Rent			65,682	64,878
Furniture, supplies, and equipment			12,919	12,954
Other administrative			36,733	35,794
			316,395	299,806
Total expense			2,320,951	1,992,845
EXCESS OF EXPENSE OVER INCOME			$1,974,428	$1,170,160

Exhibit III

RESOURCES FOR THE FUTURE, INC.

STATEMENT OF SOURCE AND APPLICATION OF CASH

	30 September	
	1971	*1970*
Cash provided by:		
Receipts from the Ford Foundation	$2,184,788	$1,625,000
Receipts from the Rockefeller Foundation	268,515	200,000
Sale of Certificates of Deposit — net		200,000
Other income received	346,523	172,685
	2,799,826	2,197,685
Cash applied to:		
Program expense	2,004,556	1,693,039
Administrative expense	316,395	299,806
Purchase of Certificates of Deposit — net	400,000	
Increase in other receivables — net	6,429	36,552
(Increase) decrease in liabilities — net	81,280	(47,085)
	2,808,660	1,982,312
Cash increase (decrease) during year	(8,834)	215,373
Cash, beginning of year	553,224	337,851
Cash, end of year	$ 544,390	$ 553,224

Exhibit IV

RESOURCES FOR THE FUTURE, INC.

STATEMENT OF GRANTS

FOR THE YEAR ENDED 30 SEPTEMBER 1971

	Unpaid 30 Sept. 1970	Changes during period		Unpaid 30 Sept. 1971
		Grants (Reductions)	Payments (Refunds)	
QUALITY OF THE ENVIRONMENT PROGRAM				
California, University of Theoretical investigation of a general equilibrium model encompassing natural resources use		$ [illegible]	$ [illegible]	
Carnegie-Mellon University Air pollution and human health		[illegible]	[illegible]	$ [illegible]
Cornell University Management and control of community noise	$ [illegible]		[illegible]	[illegible]
Florida, University of Management decisions in the agricultural use of pesticides	[illegible]			[illegible]
Harvard University Social choices by local election	[illegible]		[illegible]	[illegible]
Maryland, University of Organization of information and analysis relating to quality of life		[illegible]	[illegible]	
Michigan, University of Economic considerations in the development of wetland-shoreline management strategies for San Francisco Bay	[illegible]	[illegible]	[illegible]	[illegible]
Northwestern University Industry reactions to pollution abatement		[illegible]		[illegible]
Pennsylvania, University of Exploration of statistical relationships between air pollutants and certain chronic disease mortality rates		[illegible]	[illegible]	
Toronto, University of Public response to air pollution control measures in the United Kingdom		[illegible]		[illegible]
Miscellaneous refunds		[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]

Exhibit IV (continued)

	Unpaid 30 Sept. 1970	Changes during period: Grants (Reductions)	Changes during period: Payments (Refunds)	Unpaid 30 Sept. 1971
NATURAL ENVIRONMENTS PROGRAM				
Bowling Green State University				
The differential incidence of technological change upon the demand and supply prices for natural resource commodities	$ 6,100	$ 7,880	$ 5,792	$ 8,188
Brown University				
The optimum use of natural areas		29,278	13,000	16,278
Colorado State University				
Study of the ecology of wildlife populations		14,132	7,066	7,066
	6,100	51,290	25,858	31,532
LAND AND WATER PROGRAM				
Montana State University				
Temporal allocation of natural resources, with applications to soil and livestock range conservation	6,670			6,670
Montana, University of				
Study of wildlife management		17,756		17,756
Society of American Foresters				
Forestry curriculum development project	2,700		1,300	1,400
Southern Methodist University				
International aspects of weather modification	12,250	4,300	16,550	
Syracuse University				
United States timber supply	6,000	(280)	5,720	
Victoria, University of				
Assessment of institutional innovations in water management in England and Wales		4,800		4,800
	27,620	26,576	23,570	30,626
ENERGY AND MINERALS PROGRAM				
Adlai Stevenson Institute of International Affairs				
Feasibility of a comprehensive study of U.S. nuclear fuel policies		1,550	1,550	
Massachusetts Institute of Technology				
Statistical models of mineral exploration	9,722		9,722	
North Carolina State University				
Revision of study of supply and costs in the U.S. petroleum industry	4,695	(2,590)	1,405	
Oregon, University of				
World copper production and markets	20,708		12,000	8,708
Pennsylvania State University				
Quantitative appraisal of mineral resources	20,614	6,666	20,680	
Miscellaneous refunds		(573)	(573)	
	55,679	7,191	53,884	8,708

Exhibit IV (continued)

	Unpaid 30 Sept. 1970	Changes during period: Grants (Reductions)	Changes during period: Payments (Refunds)	Unpaid 30 Sept. 1971
REGIONAL AND URBAN PROGRAM				
Brown University				
Determinants of geographic patterns of population growth	$31,385		$31,385	
California, University of				
Conference on Regional Accounts	17,600		8,224	$9,376
Glasgow, University of				
An economic theory of the size of cities		$1,415		1,415
Conference on economic research relevant to national urban development strategies		2,800	2,800	
New York University				
Workshop in urban economics	7,500		7,500	
Interuniversity committee on urban economics	27,800		27,800	
Pennsylvania, University of				
Seminar meetings of Committee on Urban Public Economics	24,109		18,397	5,712
Princeton University				
Location choices and optimum city size	33,317		33,317	
Syracuse University				
Research and education in urban economics	15,000		15,000	
	156,711	4,215	144,423	16,503
SPECIAL PROJECTS PROGRAM				
Michigan State University				
Trends in natural resource commodities from 1957 to 1968		2,500		2,500
Washington, University of				
Regulatory system for international fisheries	19,382			19,382
Doctoral dissertation fellowships		43,738	43,738	
Miscellaneous refunds		(300)	(300)	
	19,382	45,938	43,438	21,882
LATIN AMERICAN PROGRAM				
Minnesota, University of				
Foreign investment in renewable natural resources		10,810		10,810
TOTAL GRANTS	$359,355	$233,790	$359,412	$233,733

RESOURCES FOR THE FUTURE, INC.

NOTES TO FINANCIAL STATEMENTS
FOR THE YEAR ENDED 30 SEPTEMBER 1971

Note 1 — Ford Foundation Grants

In October 1968 the Ford Foundation approved a grant of $8,000,00 for the general support of the activities of Resources for the Future fr a five-year period beginning 1 October 1969. During the year Resource for the Future received $2,000,000 of this grant which, with previos payments of $1,600,000, left a balance of $4,400,000 due at 30 Septembr 1971.

An additional grant of $295,000 was approved in January 1969 by the Ford Foundation for a special Latin American program. During th year, Resources for the Future received $134,788, which completes pa- ments for this grant.

In May 1970 the Ford Foundation approved a grant of $150,000 fr support of the doctoral dissertation fellowship program for three yeas beginning 30 September 1970. During the year a payment of $50,000 wa received leaving a balance of $100,000 due Resources for the Future t 30 September 1971.

Note 2 — Rockefeller Foundation Grant

In December 1969 the Rockefeller Foundation approved a grant f $300,000 for research on environmental quality for a two-to-three-ye period beginning 1 January 1970. Payments totalling $268,315 were r- ceived during the year which, together with previous payments f $200,000, left a balance of $31,685 due Resources for the Future at 3 September 1971.